NCEES
*advancing licensure for engineers and surveyors*

# FE

**electrical and computer**

practice exam

NCEES
*advancing licensure for engineers and surveyors*

# FE

## electrical and computer

practice exam

978-1-947801-00-4

**ISBN 978-1-947801-00-4**

Printed in the United States of America
1st printing January 2020

# CONTENTS

## About NCEES

NCEES is a nonprofit organization made up of the U.S. engineering and surveying licensing boards in all 50 states, U.S. territories, and the District of Columbia. We develop and score the exams used for engineering and surveying licensure in the United States. NCEES also promotes professional mobility through its services for licensees and its member boards.

Engineering licensure in the United States is regulated by licensing boards in each state and territory. These boards set and maintain the standards that protect the public they serve. As a result, licensing requirements and procedures vary by jurisdiction, so stay in touch with your board (ncees.org/licensing-boards).

## Exam Format

The FE exam contains 110 questions and is administered year-round via computer at approved Pearson VUE test centers. A 6-hour appointment time includes a tutorial, the exam, and a break. You'll have 5 hours and 20 minutes to complete the actual exam.

In addition to traditional multiple-choice questions with one correct answer, the FE exam uses common alternative item types such as

- Multiple correct options—allows multiple choices to be correct
- Point and click—requires examinees to click on part of a graphic to answer
- Drag and drop—requires examinees to click on and drag items to match, sort, rank, or label
- Fill in the blank—provides a space for examinees to enter a response to the question

To familiarize yourself with the format, style, and navigation of a computer-based exam, view the demo on ncees.org/ExamPrep.

## Examinee Guide

The *NCEES Examinee Guide* is the official guide to policies and procedures for all NCEES exams. During exam registration and again on exam day, examinees must agree to abide by the conditions in the *Examinee Guide*, which includes the CBT Examinee Rules and Agreement. You can download the *Examinee Guide* at ncees.org/exams. It is your responsibility to make sure you have the current version.

## Scoring and reporting

Exam results for computer-based exams are typically available 7–10 days after you take the exam. You will receive an email notification from NCEES with instructions to view your results in your MyNCEES account. All results are reported as pass or fail.

## Updates on exam content and procedures

Visit us at **ncees.org/exams** for updates on everything exam-related, including specifications, exam-day policies, scoring, and corrections to published exam preparation materials. This is also where you will register for the exam and find additional steps you should follow in your state to be approved for the exam.

# EXAM SPECIFICATIONS

## Fundamentals of Engineering (FE)
## ELECTRICAL AND COMPUTER CBT Exam Specifications

**Effective Beginning with the July 2020 Examinations**

- The FE exam is a computer-based test (CBT). It is closed book with an electronic reference.
- Examinees have 6 hours to complete the exam, which contains 110 questions. The 6-hour time also includes a tutorial and an optional scheduled break.
- The FE exam uses both the International System of Units (SI) and the U.S. Customary System (USCS).

| Knowledge | Number of Questions |
|---|---|
| **1. Mathematics** | **11–17** |
| A. Algebra and trigonometry | |
| B. Complex numbers | |
| C. Discrete mathematics | |
| D. Analytic geometry | |
| E. Calculus (e.g., differential, integral, single-variable, multivariable) | |
| F. Ordinary differential equations | |
| G. Linear algebra | |
| H. Vector analysis | |
| **2. Probability and Statistics** | **4–6** |
| A. Measures of central tendencies and dispersions (e.g., mean, mode, standard deviation) | |
| B. Probability distributions (e.g., discrete, continuous, normal, binomial, conditional probability) | |
| C. Expected value (weighted average) | |
| **3. Ethics and Professional Practice** | **4–6** |
| A. Codes of ethics (e.g., professional and technical societies, NCEES *Model Law* and *Model Rules*) | |
| B. Intellectual property (e.g., copyright, trade secrets, patents, trademarks) | |
| C. Safety (e.g., grounding, material safety data, PPE, radiation protection) | |
| **4. Engineering Economics** | **5–8** |
| A. Time value of money (e.g., present value, future value, annuities) | |
| B. Cost estimation | |
| C. Risk identification | |
| D. Analysis (e.g., cost-benefit, trade-off, break-even) | |

**5. Properties of Electrical Materials** **4–6**

A. Semiconductor materials (e.g., tunneling, diffusion/drift current, energy bands, doping bands, p-n theory)
B. Electrical (e.g., conductivity, resistivity, permittivity, magnetic permeability, noise)
C. Thermal (e.g., conductivity, expansion)

**6. Circuit Analysis (DC and AC Steady State)** **11–17**

A. KCL, KVL
B. Series/parallel equivalent circuits
C. Thevenin and Norton theorems
D. Node and loop analysis
E. Waveform analysis (e.g., RMS, average, frequency, phase, wavelength)
F. Phasors
G. Impedance

**7. Linear Systems** **5–8**

A. Frequency/transient response
B. Resonance
C. Laplace transforms
D. Transfer functions

**8. Signal Processing** **5–8**

A. Sampling (e.g., aliasing, Nyquist theorem)
B. Analog filters
C. Digital filters (e.g., difference equations, Z-transforms)

**9. Electronics** **7–11**

A. Models, biasing, and performance of discrete devices (e.g., diodes, transistors, thyristors)
B. Amplifiers (e.g., single-stage/common emitter, differential, biasing)
C. Operational amplifiers (e.g., ideal, nonideal)
D. Instrumentation (e.g., measurements, data acquisition, transducers)
E. Power electronics (e.g., rectifiers, inverters, converters)

**10. Power Systems** **8–12**

A. Power theory (e.g., power factor, single and three phase, voltage regulation)
B. Transmission and distribution (e.g., real and reactive losses, efficiency, voltage drop, delta and wye connections)
C. Transformers (e.g., single-phase and three-phase connections, reflected impedance)
D. Motors and generators (e.g., synchronous, induction, dc)

**11. Electromagnetics** **4–6**

A. Electrostatics/magnetostatics (e.g., spatial relationships, vector analysis)
B. Electrodynamics (e.g., Maxwell equations, wave propagation)
C. Transmission lines (high frequency)

**12. Control Systems** **6–9**

A. Block diagrams (e.g. feedforward, feedback)
B. Bode plots
C. Closed-loop response, open-loop response, and stability
D. Controller performance (e.g., steady-state errors, settling time, overshoot)

**13. Communications** **5–8**

A. Basic modulation/demodulation concepts (e.g., AM, FM, PCM)
B. Fourier transforms/Fourier series
C. Multiplexing (e.g., time division, frequency division, code division)
D. Digital communications

**14. Computer Networks** **4–6**

A. Routing and switching
B. Network topologies (e.g., mesh, ring, star)
C. Network types (e.g., LAN, WAN, internet)
D. Network models (e.g., OSI, TCP/IP)
E. Network intrusion detection and prevention (e.g., firewalls, endpoint detection, network detection)
F. Security (e.g., port scanning, network vulnerability testing, web vulnerability testing, penetration testing, security triad)

**15. Digital Systems** **8–12**

A. Number systems
B. Boolean logic
C. Logic gates and circuits
D. Logic minimization (e.g., SOP, POS, Karnaugh maps)
E. Flip-flops and counters
F. Programmable logic devices and gate arrays
G. State machine design
H. Timing (e.g., diagrams, asynchronous inputs, race conditions and other hazards)

**16. Computer Systems** **5–8**

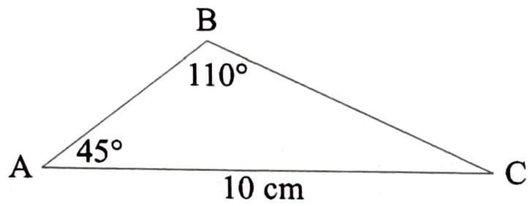
A. Microprocessors
B. Memory technology and systems
C. Interfacing

**17. Software Engineering** **4–6**

A. Algorithms (e.g., sorting, searching, complexity, big-O)
B. Data structures (e.g., lists, trees, vectors, structures, arrays)
C. Software implementation (e.g., iteration, conditionals, recursion, control flow, scripting, testing)

# PRACTICE EXAM

**1.** In the following triangle, the length (cm) of Side AB is most nearly:




- ○ A. 4.5
- ○ B. 7.1
- ○ C. 7.5
- ○ D. 192

**2.** The term $\dfrac{(1-i)^2}{(1+i)^2}$, where $i=\sqrt{-1}$ is most nearly:

- ○ A. $1+i$
- ○ B. $0$
- ○ C. $-1+i$
- ○ D. $-1$

**3.** Consider two sets, A and B, where Set A has four elements and Set B has five elements. A function $f(x)$ that maps Set A to Set B, where each element of A is mapped to a unique element of B, is:

Select **all** that apply:

- ☐ A. injective
- ☐ B. surjective
- ☐ C. bijective
- ☐ D. the inverse of the function mapping B to A
- ☐ E. an invalid general function

**4.** Three lines are defined by the three equations:

$$x + y = 0$$
$$x - y = 0$$
$$2x + y = 1$$

The three lines form a triangle with vertices at:

- ○ A. $(0, 0), \left(\frac{1}{3}, \frac{1}{3}\right), (1, -1)$
- ○ B. $(0, 0), \left(\frac{2}{3}, \frac{2}{3}\right), (-1, -1)$
- ○ C. $(1, 1), (1, -1), (2, 1)$
- ○ D. $(1, 1), (3, -3), (-2, -1)$

**5.** The only point of inflection on the curve representing the equation $y = x^3 + x^2 - 3$ is at:

- ○ A. $x = -\frac{2}{3}$
- ○ B. $x = -\frac{1}{3}$
- ○ C. $x = 0$
- ○ D. $x = \frac{1}{3}$

**6.** Given the function $f(x, y) = x^2 + xy + y^2$, solve for $\frac{\partial f}{\partial y}$.

- ○ A. $2x + x + y + 2y$
- ○ B. $2x + y$
- ○ C. $2y$
- ○ D. $x + 2y$

7. The following equation describes a second-order system:

$$\frac{d^2y}{dt^2} + 6\frac{dy}{dt} + 25y = x(t)$$

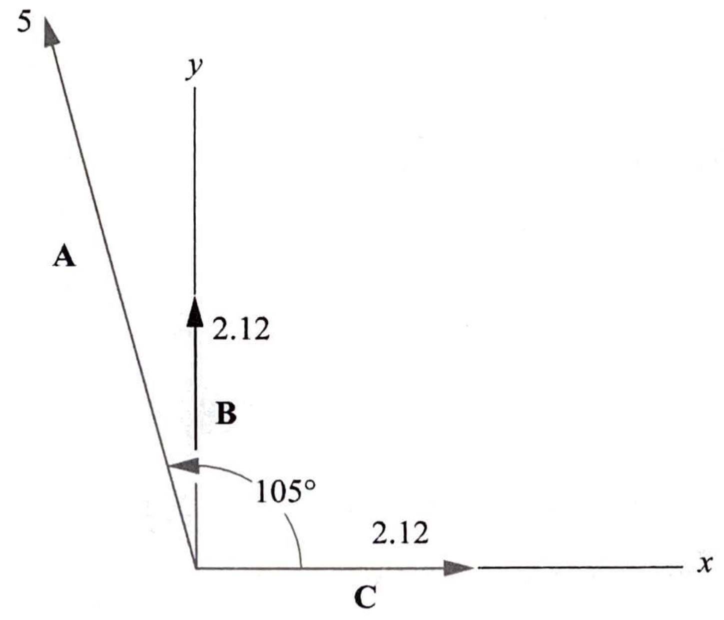
The system may be described as:

- ○ A. nonlinear
- ○ B. overdamped
- ○ C. critically damped
- ○ D. underdamped

8. The general solution to $y'' + 4y' + 4y = 0$ is:

- ○ A. $C_1e^{-4x}$
- ○ B. $C_1e^{-2x}$
- ○ C. $e^{-4x}(C_1 + C_2x)$
- ○ D. $e^{-2x}(C_1 + C_2x)$

9. The magnitude of the resultant of the three coplanar vectors **A, B,** and **C,** is most nearly:




- A. 7.0
- B. 7.8
- C. 9.2
- D. 10.3

10. Which of the following is a unit vector perpendicular to the plane determined by the vectors $\mathbf{A} = 2\mathbf{i} + 4\mathbf{j}$ and $\mathbf{B} = \mathbf{i} + \mathbf{j} - \mathbf{k}$?

- A. $-2\mathbf{i} + \mathbf{j} - \mathbf{k}$
- B. $\frac{1}{\sqrt{5}}(\mathbf{i} + 2\mathbf{j})$
- C. $\frac{1}{\sqrt{6}}(-2\mathbf{i} + \mathbf{j} - \mathbf{k})$
- D. $\frac{1}{\sqrt{6}}(-2\mathbf{i} - \mathbf{j} - \mathbf{k})$

**11.** Consider the following 2 × 2 matrix $\boldsymbol{A}$:

$$A = \begin{bmatrix} 2 & -3 \\ 4 & K \end{bmatrix}$$

The value of $K$ for which $\boldsymbol{A}$ has no inverse is most nearly:

- O A. –6
- O B. –8/3
- O C. –3/2
- O D. 6

**12.** For a series of measurements resulting in values of 11, 11, 11, 11, 12, 13, 13, 14, the arithmetic mean is 12. The median value is:

- O A. 12.5
- O B. 12.0
- O C. 11.5
- O D. 11.0

**13.** Suppose the lengths of telephone calls form a normal distribution with a mean length of 8.0 min and a standard deviation of 2.5 min. The probability that a telephone call selected at random will last more than 15.5 min is most nearly:

- O A. 0.0013
- O B. 0.0026
- O C. 0.2600
- O D. 0.9987

14. You have a fair coin that you toss ten times. The probability of getting exactly four heads in ten tosses is most nearly:

- O A. 0.1
- O B. 0.2
- O C. 0.4
- O D. 0.5

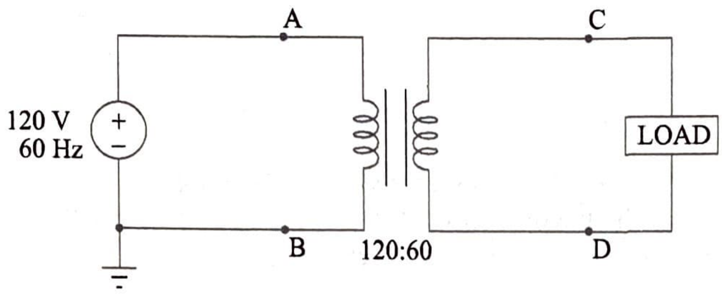
15. An engineer has been asked to evaluate several projects for planning the following fiscal year. The probability of success and the payoff of the project, if successful, are shown. Given these values, rank the projects from lowest to highest expected payoff.

| **Project** | **Probability of Success** | **Payoff** | **Ranking (lowest to highest)** |
|---|---|---|---|
| Project A | 40% | \$3,500,000 | |
| Project B | 65% | \$1,250,000 | |
| Project C | 75% | \$2,750,000 | |

16. You are a student and have an on-site job interview with Company A. Just before you fly to the interview, you get a call from Company B asking you to come for an on-site interview at their offices in the same city. When you inform them of your interview with Company A, they suggest you stop in after that. Company A has already paid for your airfare and, at the conclusion of your interview with them, issues you reimbursement forms for the balance of your trip expenses with instructions to file for all of your trip expenses. When you inform them of your added interview stop at Company B, they tell you to go ahead and charge the entire cost of the trip to Company A. You interview with Company B, and at the conclusion, they give you travel reimbursement forms with instructions to file for all of your trip expenses. When you inform them of the instructions of Company A, they tell you that the only expenses requiring receipts are airfare and hotel rooms, so you should still file for all the other expenses with them even if Company A is paying for it because students always need a little spending money. What should you do?

- O A. File for travel expenses with only one firm.
- O B. Do as both recruiting officers told you. It is their money and their travel policies.
- O C. File for travel expenses from both firms so you receive double your expense cost.
- O D. Tell all of your classmates to sign up to interview with these firms for the trips.

**17.** An ideal transformer connects a 120-V, 60-Hz voltage source to a load. One terminal of the voltage source is grounded. The load is ungrounded. The circuit and transformer are operating normally (not in a fault condition). A person whose body is contacting ground is in proximity to the circuit. If the person touches the circuit, which point (A, B, C, or D) likely has the highest risk of resulting in a shock?




- ○ A. Point A
- ○ B. Point B
- ○ C. Point C
- ○ D. Point D

**18.** An engineer judges that a design poses a threat to human life and recommends to management that the design be modified. The manager, who is not an engineer, overrules the recommendation. According to the *Model Rules*, the engineer must:

- ○ A. resign from the job
- ○ B. inform the employer, and any other appropriate authority, of the problem
- ○ C. contact the press and make it clear that this is a professional opinion
- ○ D. comply with the manager's ruling

**19.** According to the *Model Rules*, Section 240.15, Rules of Professional Conduct, licensed professional engineers are obligated to:

- ○ A. ensure that design documents and surveys are reviewed by a panel of licensed engineers prior to affixing a seal of approval
- ○ B. express public opinions under the direction of an employer or client regardless of knowledge of subject matter
- ○ C. practice by performing services only in the areas of their competence and in accordance with the current standards of technical competence
- ○ D. offer, give, or solicit services, directly or indirectly, in order to secure work, political favors, or other valuable considerations

**20.** The annual nominal interest rate on the unpaid portion of a contract is 17%. If the interest is compounded quarterly, the effective interest rate is most nearly:

- ○ A. 14%
- ○ B. 16%
- ○ C. 18%
- ○ D. 20%

**21.** A printer costs \$900. Its salvage value after 5 years is \$300. Annual maintenance is \$50. If the interest rate is 8%, the equivalent uniform annual cost is most nearly:

- ○ A. \$224
- ○ B. \$300
- ○ C. \$327
- ○ D. \$350

**22.** A project has the estimated cash flows shown below.

| **Year End** | **0** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|---|
| **Cash Flow** | –$1,100 | –$400 | +$1,000 | +1,000 | +1,000 |

With an interest rate of 12% per year compounded annually, the annual worth of the project is most nearly:

- A. $450
- B. $361
- C. $320
- D. $226

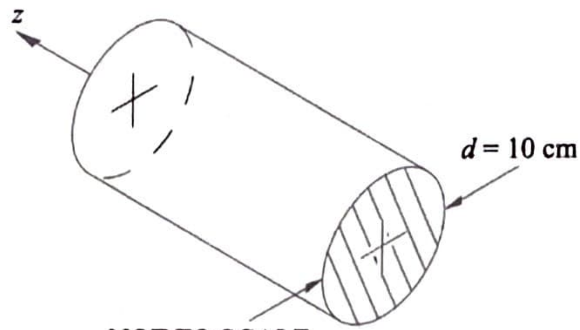
**23.** Which of the following situations is most appropriate for using breakeven analysis?

- A. Calculating the interest rate that will ensure that costs and returns are equal
- B. Determining the number of units to produce to ensure that income covers expenses
- C. Establishing the minimum return on an investment over a set number of years
- D. Forecasting the amount of product that must be produced to meet a set profit margin

**24.** An electric utility owns and maintains 5,000 miles of overhead distribution lines. The annual incidence of downed conductors on these lines (due to vehicular accidents, equipment failure, etc.) is 0.001 incidents per circuit mile. For each incident, there is a 5% chance that a human contacts a downed, energized conductor before it can be detected and de-energized. In these situations, 50% of human contact results in a fatality. The risk to human life, in fatalities/year, due to downed conductors on the utility's distribution system is most nearly:

- A. 0.025
- B. 0.125
- C. 0.250
- D. 2.500

**25.** The solid cylindrical conductor shown below carries a uniform direct current with a density of 100 A/m$^2$ in the positive $z$ direction. Assume the resistivity is 0.1 Ω·m.




NOT TO SCALE

The power loss (W) per meter of length is most nearly:

- O A. 2.50
- O B. 3.93
- O C. 7.85
- O D. 31.42

**26.** At 80°F the contact potential for a given p-n junction is 0.026 V. If the temperature is raised to 180°F, the increase (mV) in the contact potential will be ___________.

Enter your response in the blank.

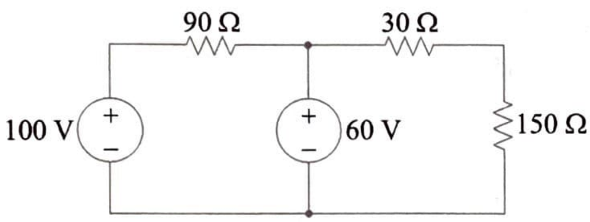
**27.** A section of copper has resistivity of 10 Ω·m at 20°C. The temperature coefficient of copper is 0.004041 Ω/°C. If the temperature is increased to 30°C, the resistivity (Ω·m) is most nearly:

- O A. 8.96
- O B. 10.04
- O C. 11.04
- O D. 11.20

**28.** A platinum-type resistance temperature detector (RTD) has a terminal resistance of 200 Ω at 0°C. At 125°C, the terminal resistance of the same RTD is 300 Ω. The temperature coefficient [Ω/(Ω·°C)] of the RTD is most nearly:

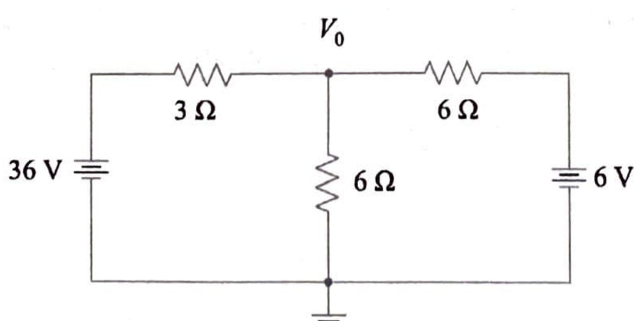
- O A. 0.004
- O B. 0.008
- O C. 0.417
- O D. 0.667

**29.** The power (W) dissipated in the 90-Ω resistor of the circuit shown below is most nearly:



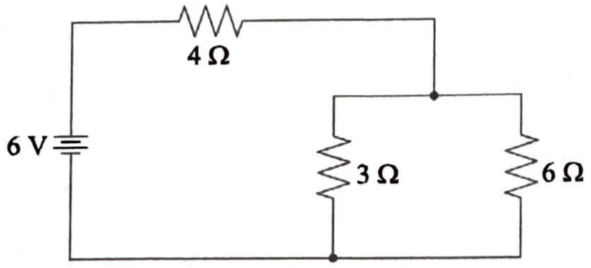

- O A. 8
- O B. 18
- O C. 40
- O D. 71

**30.** In the circuit shown, voltage $V_0$ (V) is most nearly:



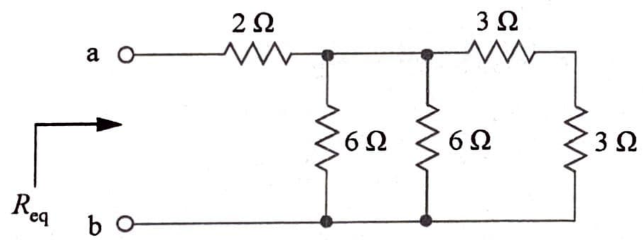

- O A. 19.5
- O B. 18.5
- O C. 16.5
- O D. 3.0

31. The current (amperes) through the 6-Ω resistor is most nearly:




- A. 1/3
- B. 1/2
- C. 1
- D. 3/2

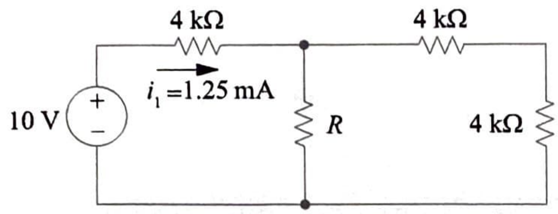
32. In the resistor circuit shown below, the equivalent resistance $R_{eq}$ (Ω) at Terminals a-b is most nearly:



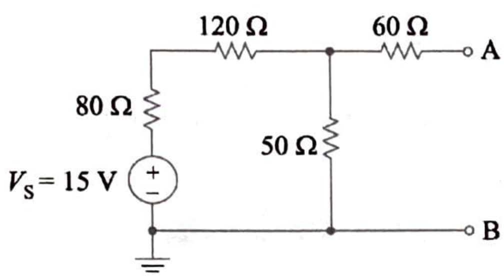

- A. 22
- B. 20
- C. 4
- D. 2

**33.** In the figure below, the value (kΩ) of $R$ needed to make $i_1 = 1.25$ mA is ___________.

Enter your response in the blank.

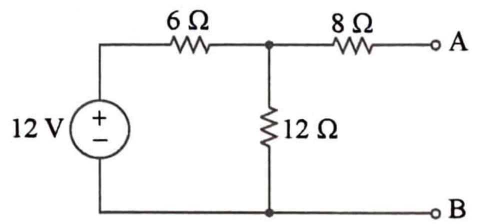



**34.** The Norton equivalent resistance (Ω) at Terminals A-B is most nearly:




- A. 50
- B. 60
- C. 100
- D. 120

**35.** Consider the following circuit:




The Thévenin equivalent resistance (Ω) at Points A-B is most nearly:

- O A. 8
- O B. 12
- O C. 20
- O D. 26

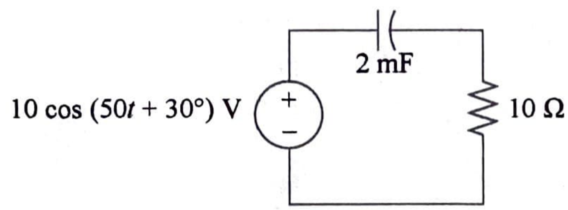
**36.** Two waveforms are represented by the following equations:

$$i_1 = 10 \cos(\omega t) - 7 \cos(3\omega t) - 3 \sin(5\omega t)$$
$$i_2 = 10 \sin(\omega t) + 3 \cos(3\omega t) + 7 \cos(5\omega t)$$

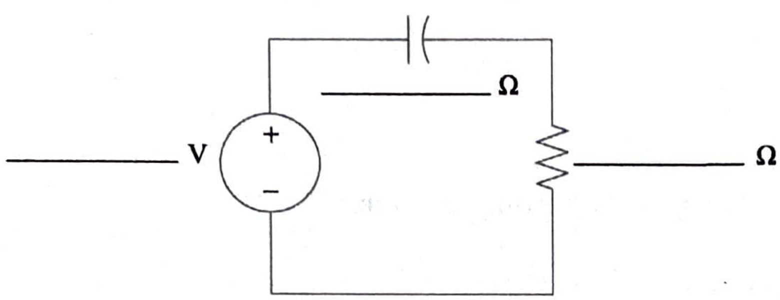
How do their RMS values compare?

- O A. RMS values of $i_1(t)$ and $i_2(t)$ are nonzero and equal.
- O B. RMS value of $i_1(t)$ is larger than that of $i_2(t)$.
- O C. RMS value of $i_1(t)$ is smaller than that of $i_2(t)$.
- O D. RMS values of $i_1(t)$ and $i_2(t)$ are each zero.

**37.** Consider the following circuit in the time domain:




Label the circuit below with component values that yield the equivalent circuit in the frequency (phasor) domain.




**Component Values**

10

$j10$

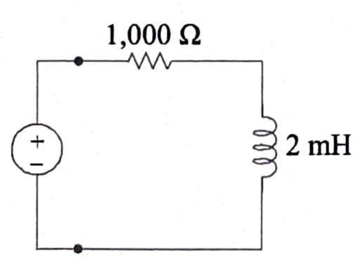
$-j10$

$-j0.1$

$7.07 \angle 30°$

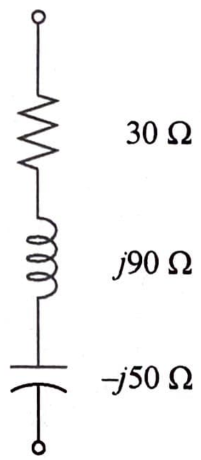
$7.07 \angle -60°$

**38.** A 1,000-Ω resistor is in series with a 2-mH inductor. An ac voltage source operating at a frequency of 100,000 rad/s is attached as shown in the figure. The impedance (Ω) of the *RL* combination is most nearly:

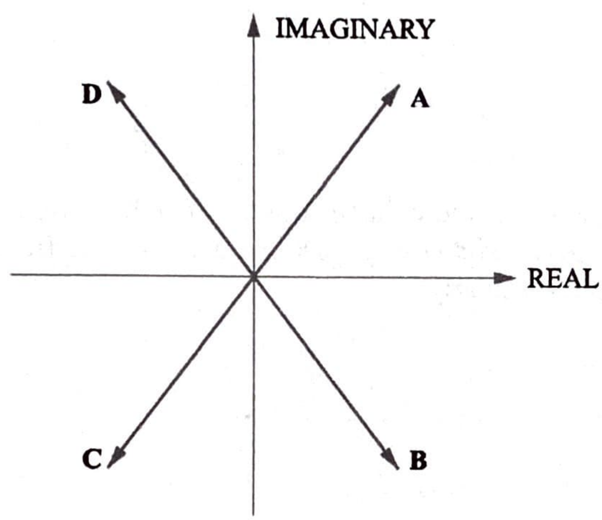



- ○ A. $200 + j1{,}000$
- ○ B. $1{,}000 + j200$
- ○ C. $38.4 + j192$
- ○ D. $1{,}000 - j200$

**39.** Series-connected circuit elements are shown in the figure below.

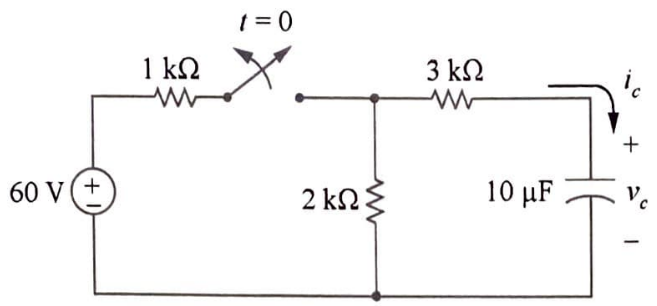



Which of the vectors shown represents the total impedance?




- ○ A. Vector A
- ○ B. Vector B
- ○ C. Vector C
- ○ D. Vector D

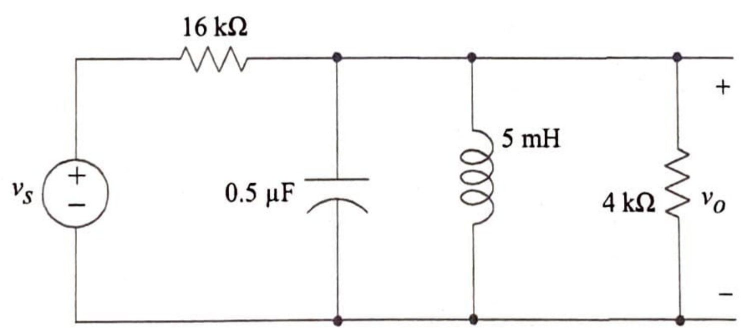
**40.** After having been closed for a long time, the switch shown in the figure is opened at $t = 0$.




The expression for $v_c$ (V) for $t > 0$ is most nearly:

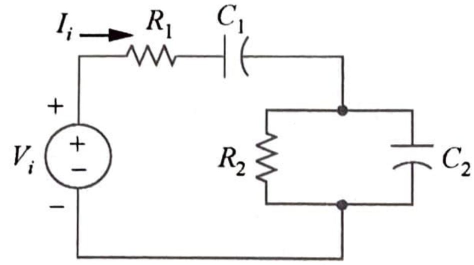
- A. $20\ e^{-50t}$
- B. $20\ e^{-0.2t}$
- C. $40\ e^{-200{,}000t}$
- D. $40\ e^{-20t}$

**41.** In the circuit shown below, the frequency of the voltage source $v_s$ can be varied over a broad range of frequencies while the amplitude of its voltage is kept constant. The frequency (kHz) at which $v_o$ has maximum amplitude is most nearly:




- A. 1.59
- B. 3.18
- C. 15.9
- D. 31.8

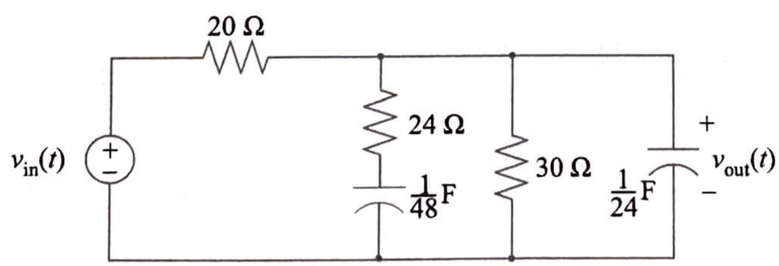
**42.** Consider the following network:




The driving point impedance (input impedance) has poles at:

- O A. $s = 0$ and $s = -\dfrac{1}{R_2C_2}$
- O B. $s = -\dfrac{1}{R_1C_1}$ and $s = -\dfrac{1}{R_2C_2}$
- O C. $s = 0$ and $s = -\dfrac{1}{R_1C_2}$
- O D. $s = -\dfrac{1}{R_1C_2}$ and $s = -\dfrac{1}{R_2C_1}$

**43.** The circuit shown below has a transfer function given by $\dfrac{V_{\text{out}}}{V_{\text{in}}} = \dfrac{1.2(s+2)}{(s+1)(s+4)}$. The voltage source $v_{\text{in}}(t)$ is a unit step function, and there is no initial charge on the capacitors. The final (steady-state) value (V) of $v_{\text{out}}(t)$ is most nearly:




- O A. 0
- O B. 0.04
- O C. 0.55
- O D. 0.60

**44.** A time-domain signal $f(t)$ is represented by the following expression in the frequency domain:

$$F(s) = \frac{3}{s^2 + 4s}$$

The final value of $f(t)$ is most nearly:

- A. 0
- B. 0.75
- C. 1.33
- D. $\infty$

**45.** A digital filter with input $x[k]$ and output $y[k]$ is described by the difference equation:

$$y[k] = \frac{1}{6}\left(3x[k] + 2x[k-1] + x[k-2]\right)$$

The discrete-time transfer function of the filter $H(z)$ is:

- A. $\dfrac{6z^2}{3z^2 + 2z + 1}$
- B. $\dfrac{6z}{3z^2 + 2z + 1}$
- C. $3z^2 + 2z + 1$
- D. $\dfrac{1}{6}\left[\dfrac{3z^2 + 2z + 1}{z^2}\right]$

46. The sifting property of the impulse (delta) function $\delta(t)$ is defined as

$$\int_{-\infty}^{\infty} f(t)\delta(t-a)dt = f(a)$$

The value of the following integral

$$\int_{-\infty}^{\infty} \cos(\omega t)\delta(t-1)dt$$

where $\omega = 2$ rad/s and $t$ is in seconds is most nearly:

- ○ A. –0.4161
- ○ B. 0
- ○ C. 0.9093
- ○ D. 1.0

47. You are designing a digital speed-monitoring system for the cruise control of a new automobile. A tachometer sensor produces a square wave signal with a 50% duty cycle. Each pulse corresponds to one full rotation of the rear right tire. The tires are 24 inches in diameter. The vehicle's absolute top speed is 100 mph.

The sensor signal is low-pass filtered with a cutoff frequency between the tenth and eleventh harmonic of the signal. The minimum sampling frequency (samples per second) required to avoid aliasing when the vehicle is at its top speed is most nearly:

- ○ A. 23.4
- ○ B. 234
- ○ C. 467
- ○ D. 1,000

**48.** The transfer function for a filter is:

$$H(j\omega) = \frac{j\omega}{1 + j\omega}$$

This filter is best classified as a:

- O A. low-pass filter
- O B. high-pass filter
- O C. band-pass filter
- O D. notch filter

**49.** A digital filter with input $x[n]$ and output $y[n]$ is represented by the difference equation

$$y[n] = \frac{1}{2}x[n] + \frac{1}{3}y[n-1]$$

The impulse response for this filter is most nearly:

- O A. $h[n] = 2\delta[n] - \frac{2}{3}\delta[n-1]$
- O B. $h[n] = \frac{1}{2}\delta[n] - \frac{1}{3}\delta[n-1]$
- O C. $h[n] = \frac{1}{2}\left(\frac{1}{3}\right)^n, n \geq 0$
- O D. $h[n] = \frac{1}{2}\left(-\frac{1}{3}\right)^n, n \geq 0$

**50.** The gate-to-source voltage of the depletion-mode, n-channel MOSFET shown in the circuit below is 1 V. The various operating regions of the MOSFET are described below:

Cutoff Region: ($v_{GS} < V_p$)

$i_D = 0$

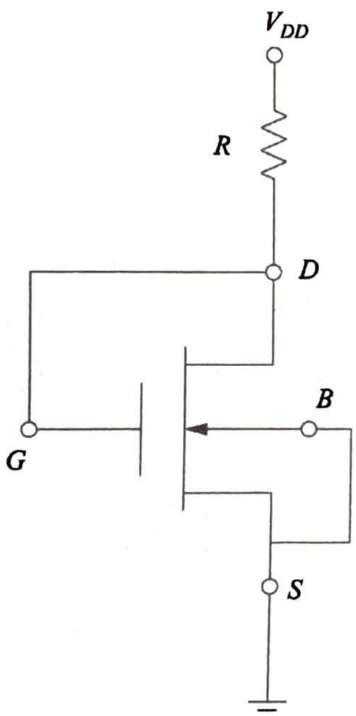
Triode Region: ($v_{GS} > V_p$ and $v_{GD} > V_p$)

$i_D = K\,[2\,(v_{GS} - V_P)\,v_{DS} - v_{DS}^2]$

Saturation Region: ($v_{GS} > V_P$ and $v_{GD} < V_P$)

$i_D = K(v_{GS} - V_p)^2$

If $K = 0.2$ mA/V² and $V_p = -4$ V, the value of $i_D$ (mA) is most nearly:

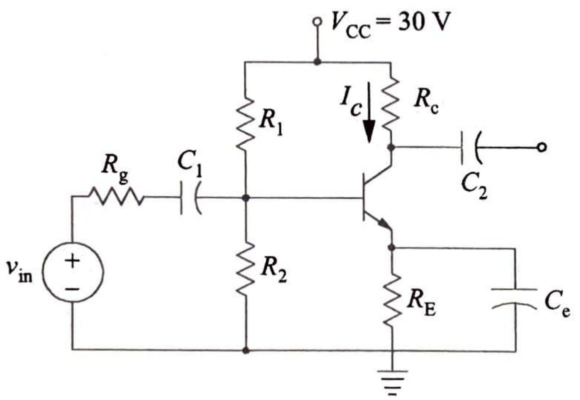



- A. 5
- B. 2.2
- C. 1.8
- D. 0

51. An n-channel JFET has a pinch-off voltage $V_p$ of $-4$ V and $I_{DSS}$ of 16 mA. This device is to operate in the saturation region. When the quiescent drain current is 4 mA, the gate-to-source voltage (V) required to give this operating point is most nearly:

- ○ A. −2.0
- ○ B. −2.5
- ○ C. −3.0
- ○ D. −4.0

52. Let $R_C = 600\ \Omega$, and let $R_E = 500\ \Omega$. When $R_1 = 2.00\ \text{k}\Omega$ and $R_2 = 1.00\ \text{k}\Omega$, the value of $I_C$ (mA) is most nearly:



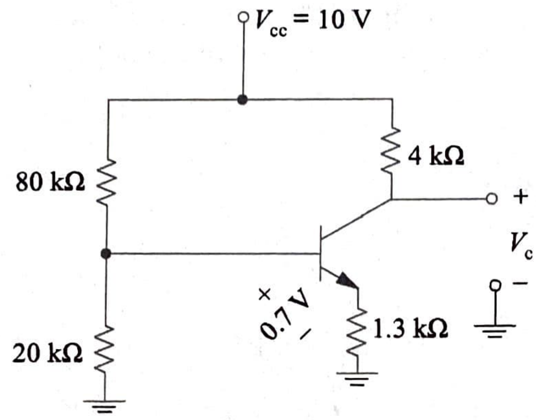

$R_g = 100\ \Omega$ $\qquad C_e = 50.0\ \mu F$

$C_1 = 10.0\ \mu F$ $\qquad V_{BE} = 0.7$ V

$C_2 = 10.0\ \mu F$

- ○ A. 10
- ○ B. 19
- ○ C. 24
- ○ D. 27

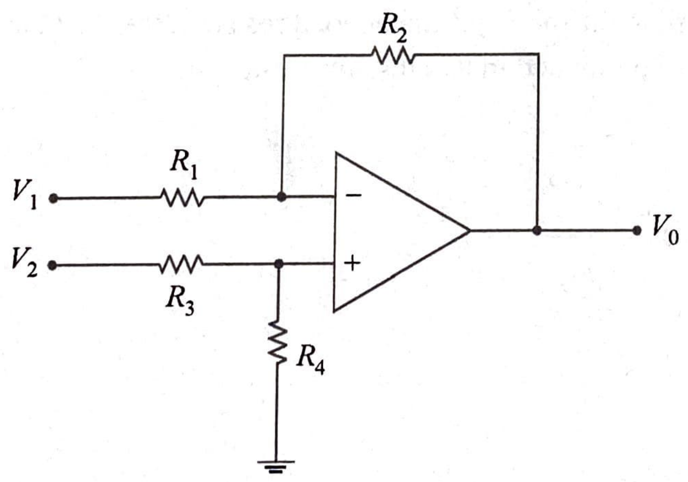
**53.** The transistor in the circuit below has a very high value of β.




The value (V) of the collector voltage $V_c$ is most nearly:

- O A. 6.0
- O B. 4.0
- O C. 2.0
- O D. 1.3

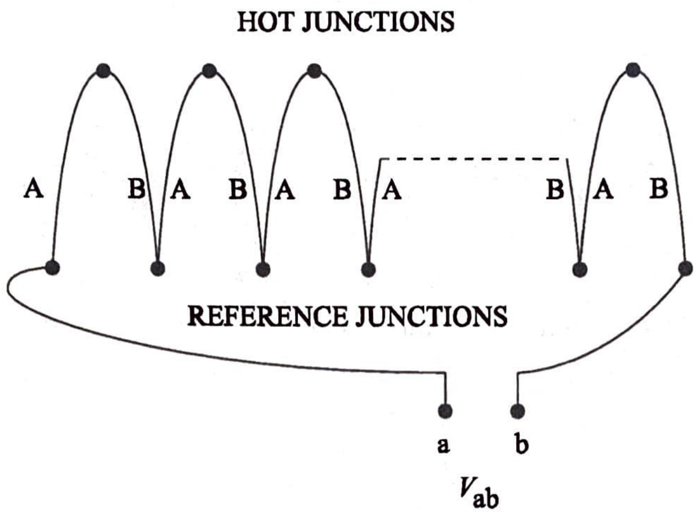
**54.** An ideal operational amplifier is to be connected as a differential amplifier as shown in the diagram below. Nominally, $R_1 = R_3 = 5$ kΩ and $R_2 = R_4 = 200$ kΩ.




The gain for an input $V_2$ with the input $V_1$ grounded is most nearly:

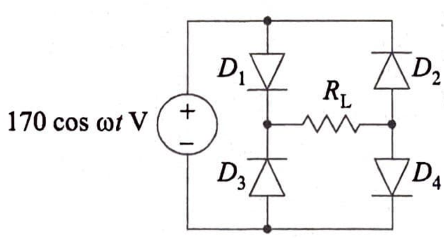
- O A. 20
- O B. 35
- O C. 40
- O D. 41

**55.** Wires of two dissimilar metals, A and B, develop an open-circuit voltage of 45 μV per °C of temperature difference above a reference temperature. A thermopile consists of 50 thermocouples connected in series as shown in the figure. The reference junctions are maintained at 60°C, and $V_{ab}$ is measured to be 60 mV. The temperature (°C) of the hot junctions is most nearly:




- ○ A. 27
- ○ B. 87
- ○ C. 1,330
- ○ D. 1,390

**56.** In the full-wave bridge rectifier circuit shown, if the dc load resistor $R_L$ = 10 Ω and the diodes are ideal, the average power (W) dissipated in this resistor is most nearly:




- ○ A. 723
- ○ B. 1,445
- ○ C. 1,700
- ○ D. 2,890

**57.** A 3-phase induction motor is operating at a speed of $n = 3{,}500$ rpm with a line voltage of 240 V at 60 Hz. The number of poles this motor has is most nearly:

- O A. 2
- O B. 4
- O C. 5.83
- O D. 6

**58.** A pump station uses an induction motor that requires a complex power of:

$$S_1 = 20 \angle 36.87° \text{ kVA}$$

and a synchronous motor that requires a complex power of:

$$S_2 = 10 \angle -53.13° \text{ kVA}$$

The total reactive power (kvar) required by the pump station is most nearly:

- O A. 4
- O B. 20
- O C. 22
- O D. 30

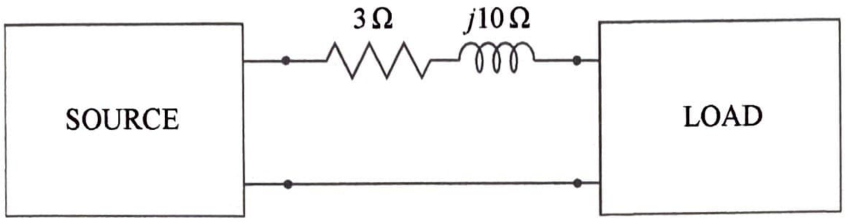
**59.** A balanced 3-phase load is rated at 100 kVA and 0.65 pf lagging. A purely capacitive load is added in parallel with the inductive load to improve the power factor to 0.9 lagging. The capacitive load must supply a reactive power (kvar) that is most nearly:

- O A. 76
- O B. 65
- O C. 45
- O D. 31

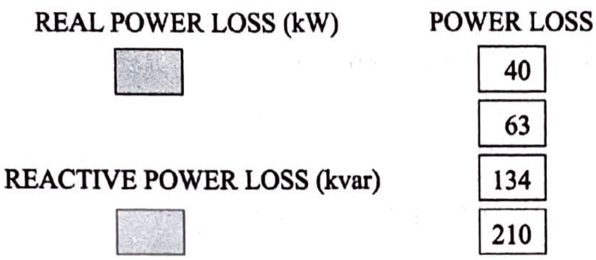
**60.** Assume a 120-V, single-phase source is feeding a load of $7 + j12\ \Omega$ through a line impedance of $2 + j0\ \Omega$. The magnitude (V) of the voltage drop across the line is most nearly:

- O A. 16
- O B. 27
- O C. 97
- O D. 111

**61.** A single-phase load is connected to a single-phase source via a transmission line with impedance $3 + j10\ \Omega$. The load operates at a voltage of 13,800 V and consumes 2 MVA at 0.8 lagging power factor. There are real and reactive power losses in the transmission line.




Match the correct amount to the type of loss. Values can be used only one time.

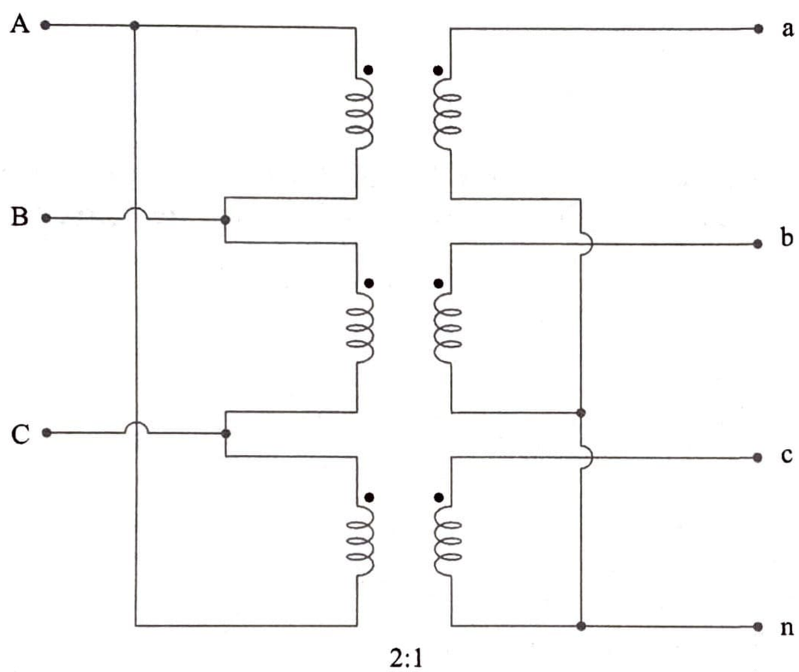



**62.** A single-phase ideal transformer has a primary-to-secondary turns ratio of 4:1. If the secondary impedance is $2\ \Omega$, the reflected impedance ($\Omega$) as seen on the primary is most nearly:

- ○ A. 0.5
- ○ B. 2.0
- ○ C. 8.0
- ○ D. 32.0

**63.** Three identical ideal transformers are connected as shown to create a 3-phase transformer. The primary-to-secondary ratio of each of the ideal transformers is 2:1. The primary of the 3-phase transformer is connected in delta ($\Delta$) and the secondary is connected in wye (Y). If the balanced line-to-line voltage of 240 $V_{rms}$ is applied to the primary of the 3-phase transformer, the rms value (V) of the line-to-line voltage on the secondary of the 3-phase transformer is __________.

Enter your response in the blank.



**64.** A 2-pole, 60-Hz, Y-connected synchronous generator is connected to a 3-phase, Y-connected load. The mechanical torque applied to the generator shaft is 1,000 N·m. The internal losses are 50 kW, and the load operates at 480 V (line-to-line). The excitation (i.e., field current) is adjusted such that the output power factor is 0.8 lagging. The magnitude of the generator's line current (amperes) is most nearly:

- O A. 320
- O B. 490
- O C. 640
- O D. 850

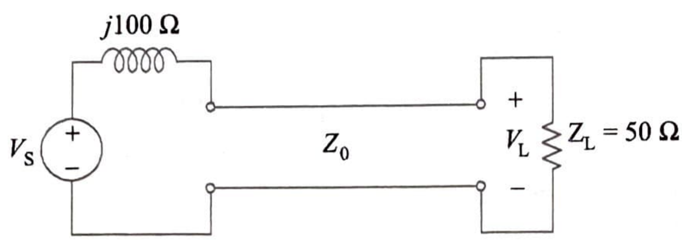
**65.** One tesla represents a very strong magnetic flux density. The current (amperes) required in a long straight wire to produce a 1-tesla flux density 0.5 m from the wire in free space (use $\mu = \mu_0$) is most nearly:

- O A. $1.25 \times 10^6$
- O B. $2.5 \times 10^6$
- O C. $5 \times 10^6$
- O D. $25 \times 10^6$

**66.** A coaxial cable transmission line is known to have a characteristic impedance of 50 Ω. Measurement of the capacitance between the center conductor and the outer shield indicates a capacitance per unit length of 133 pF/m. The inductance per unit length of the coaxial cable is most nearly:

- O A. 6.6 nH/m
- O B. 33 nH/m
- O C. 0.33 μH/m
- O D. 3.3 μH/m

**67.** The following circuit contains a lossless transmission line with a characteristic impedance of $Z_0 = 50\ \Omega$. The magnitude of the load voltage $V_L$ is 200 $V_{rms}$.




The magnitude of the source voltage $V_S$ ($V_{rms}$) is most nearly:

- A. 100.0
- B. 200.0
- C. 282.8
- D. 447.2

**68.** An electromagnetic plane wave with an angular frequency of $\omega = 4.518 \times 10^{10}$ rad/s propagates in the $+z$ direction through a conducting medium. The medium is characterized by $\sigma = 0.2$ S/m, $\varepsilon = \varepsilon_0 = 8.8534 \times 10^{-12}$ F/m, and $\mu = \mu_0 = 4\pi \times 10^{-7}$ H/m. The associated electric field is represented in phasor form as:

$$\vec{E} = E_{x0} e^{-\gamma z} \hat{x}$$

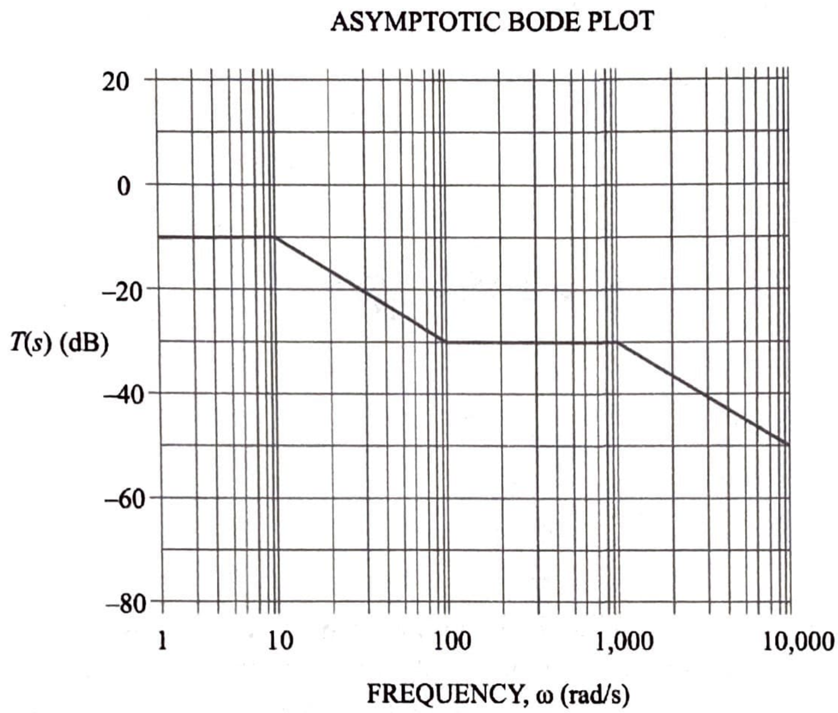
where $\gamma$ is the propagation constant given by:

$$\gamma = j\omega\sqrt{\mu_0 \varepsilon_0}\sqrt{1 - \frac{j\sigma}{\omega\varepsilon_0}}$$

The value of $z$ (in meters) for which the magnitude of the electric field is $0.01E_{x0}$ is most nearly:

- A. 0.00273
- B. 0.0289
- C. 0.0297
- D. 0.1259

**69.** The asymptotic Bode plot for the magnitude of the transfer function $T(s)$ is shown in the figure below. The transfer function $T(s)$ in terms of the asymptotic Bode plot is most nearly:



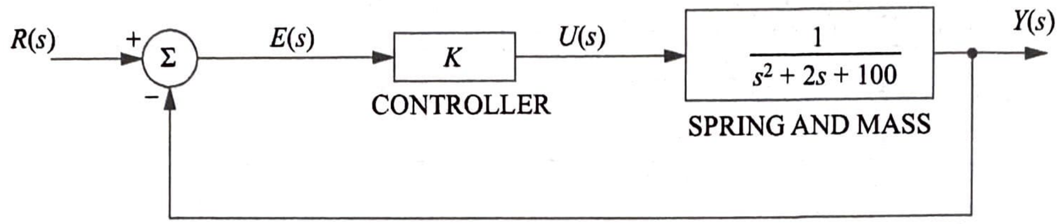

○ A. $T(s) = K\dfrac{(s+100)}{(s+10)(s+1{,}000)}$

○ B. $T(s) = K\dfrac{(s+100)}{s(s+10)(s+1{,}000)}$

○ C. $T(s) = K\dfrac{s(s+100)}{(s+10)(s+1{,}000)}$

○ D. $T(s) = K\dfrac{(s+10)(s+1{,}000)}{(s+1)(s+100)}$

**70.** A proportional controller with gain $K$ is used to control a spring and mass system as shown in the figure below.



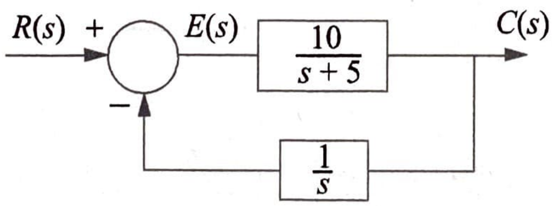

If $K$ is adjusted so that the second-order, closed-loop system model is $\frac{Y(s)}{R(s)} = \frac{50}{s^2 + 2s + 150}$, then the system damping ratio is most nearly:

- ○ A. 0.8
- ○ B. 0.08
- ○ C. 0.0067
- ○ D. 0

**71.** The closed-loop, negative feedback control system shown has the transfer function:

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1 + G(s)H(s)} = \frac{10s}{s^2 + 5s + 10}$$

If $r(t)$ is a unit step input, the steady-state error $e(t)$ is most nearly:



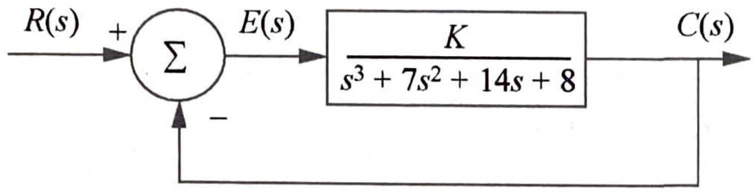

- ○ A. 0
- ○ B. 1
- ○ C. 2
- ○ D. $\infty$





NEXT→

**72.** A unity-feedback control system is shown in the figure below.



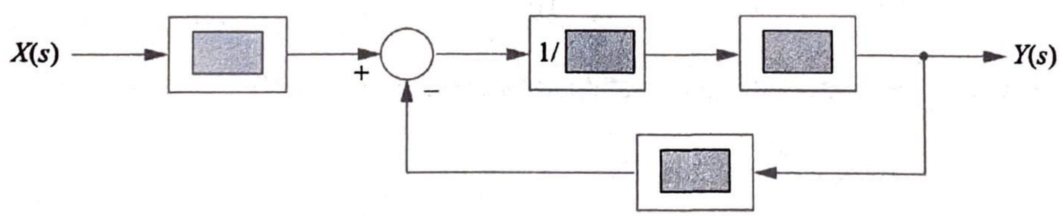

The number of poles in the open-loop characteristic equation for this system is most nearly:

- ○ A. 0
- ○ B. 1
- ○ C. 2
- ○ D. 3

**73.** The transfer function for the block diagram below is given by:

$$\frac{Y(s)}{X(s)} = \frac{B(s)\,C(s)}{D(s)+A(s)\,C(s)}$$

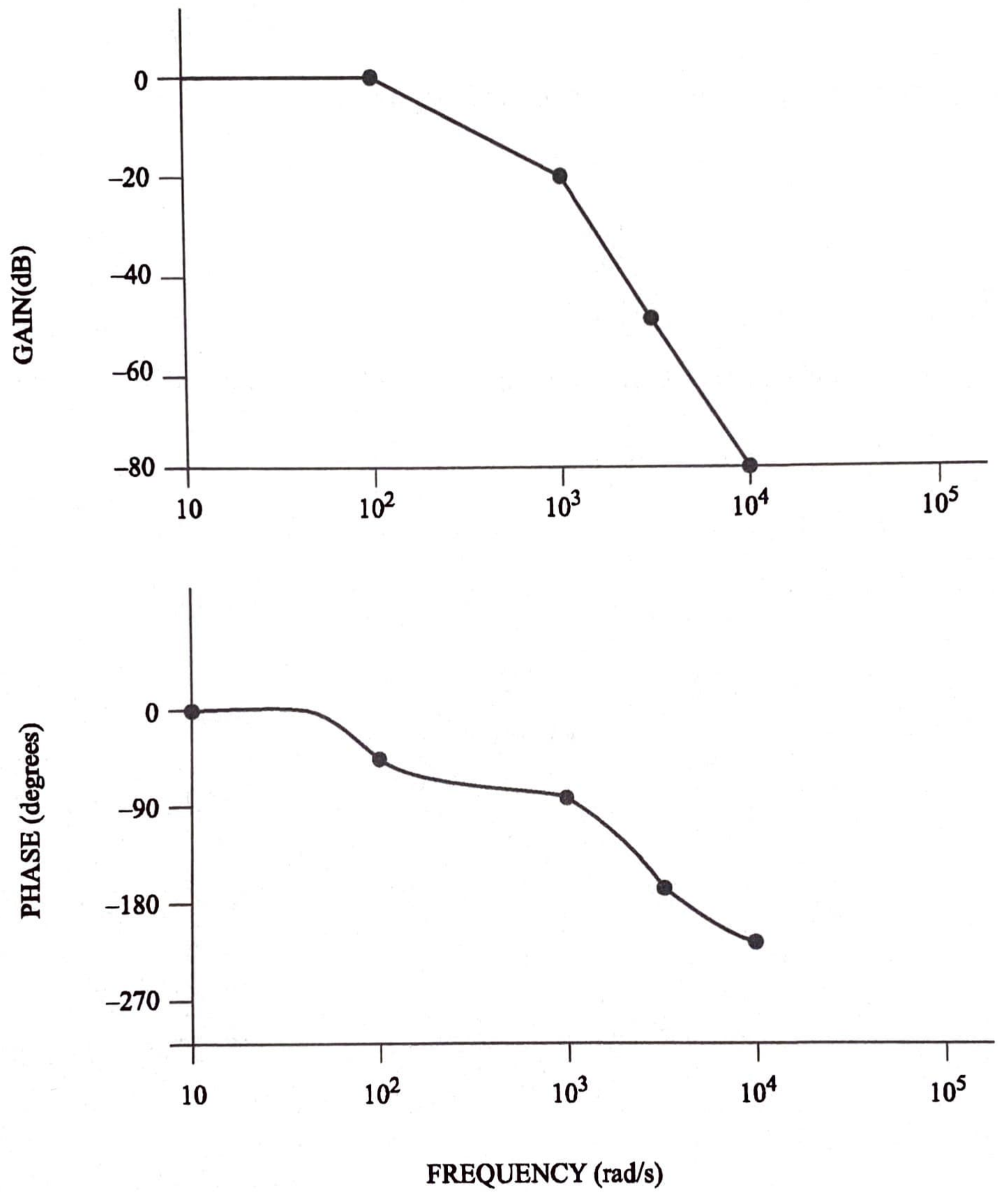
Place the functions for $A(s)$, $B(s)$, $C(s)$, and $D(s)$ in the correct shaded locations on the block diagram.



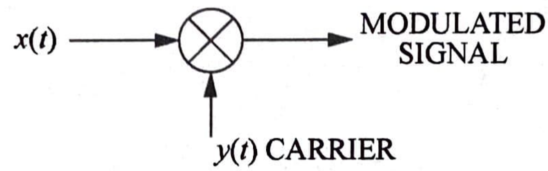

Functions: $A(s)$ $B(s)$ $C(s)$ $D(s)$

**74.** The open-loop Bode plot for a unity negative feedback control system is shown below. For this control system, the gain margin (dB) is most nearly:

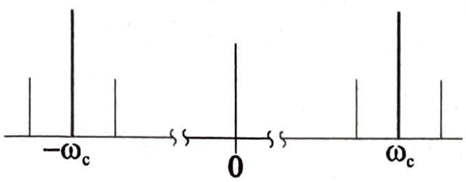
- O A. –50
- O B. 0
- O C. 20
- O D. 50



**75.** A signal $x(t) = 1 + 0.8 \sin(50t)$ V modulates an AM carrier $y(t) = 2 \sin(1{,}000t)$ V by multiplying the two signals as shown below:



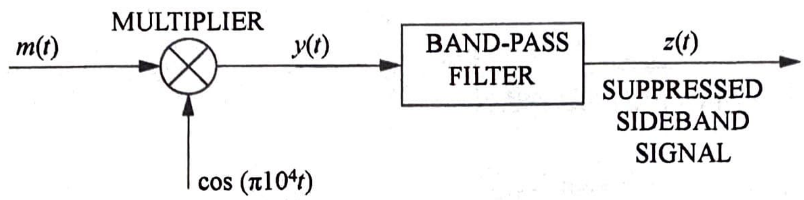

The two-sided magnitude spectrum of the modulated signal is shown below:




The normalized power (W) into a 1-Ω resistor contained in the signal at 1,050 rad/s is most nearly:

- O A. 0.32
- O B. 0.64
- O C. 0.80
- O D. 1.28

**76.** A portion of a voice communication system is shown below. The audio message $m(t)$ is in the range 20 Hz to 500 Hz. The signal $m(t)$ is used to modulate a cosine carrier signal as shown below.




The center frequency (Hz) and bandwidth (Hz), respectively, of an ideal band-pass filter required to suppress the lower sideband and the carrier of $y(t)$ to produce $z(t)$ are most nearly:

- A. 250; 250
- B. 0; 1,000
- C. 5,250; 500
- D. 4,750; 500

**77.** A 10-MHz carrier is AM-modulated by a symmetrical square wave with a period of 1 ms. The bandwidth (kHz) of a filter with a center frequency of 10 MHz required to transmit the square wave with the first five nonzero components ($n = 1, 3, 5, 7, 9$) of its Fourier components is most nearly:

- A. 3
- B. 6
- C. 10
- D. 20

**78.** When data is transmitted in a serial format, an error detection bit called a parity bit may be appended to the bit stream. A serial receiver that uses even parity has received the following nine bits (parity bit followed by eight data bits).

000110100

Which statement best describes the received code?

- O A. No errors occurred during transmission.
- O B. An odd number of bits have been corrupted during transmission.
- O C. An even number of bits have been corrupted during transmission.
- O D. A bit transmitted as a one (1) has been changed to a zero (0) during transmission.

**79.** A listener can tune a car radio to one AM radio station out of several AM radio stations simultaneously broadcasting on the AM radio band. The process allowing multiple AM radio stations to coexist within a single band is called:

- O A. time-division multiplexing
- O B. amplitude-division multiplexing
- O C. frequency-division multiplexing
- O D. quadrature multiplexing

**80.** In computer networks, the primary function of a router is to:

- O A. connect two or more computers on the same local area network
- O B. connect a computer to the Ethernet
- O C. connect local area networks
- O D. detect collisions of data packets from computers on the network and retransmit them as necessary

**81.** Most computer networks use packet switching to move data from the transmitting computer to the receiving computer. The following properties apply to packet-switched networks:

Select **all** that apply.

☐ A. The size of the data blocks is limited.
☐ B. The $n^{th}$ packet of a message may be forwarded before the $(n + 1)$ packet has fully arrived.
☐ C. The path from transmitting to receiving must be established before transmission starts.
☐ D. Packets may be delivered to the destination in the wrong order.
☐ E. The required bandwidth is reserved in advance. Thus, any unused bandwidth is wasted.

**82.** The transport layer of the OSI framework provides a mechanism for the exchange of data between end systems. Examples of protocols that operate on the transport layer include:

O A. IP and TCP
O B. IP and UDP
O C. TCP and UDP
O D. IP, TCP, and UDP

**83.** Which of the following is an appropriate configuration to implement multifactor authentication as defined by NIST?

O A. Password and PIN
O B. Retinal scan and thumbprint
O C. Thumbprint and PIN
O D. Keycard and token

**84.** Which of the following is a binary representation of the base-10 fraction $\frac{93}{128}$?

- ○ A. 0.1011100
- ○ B. 0.1011101
- ○ C. 0.1011110
- ○ D. 0.1011111

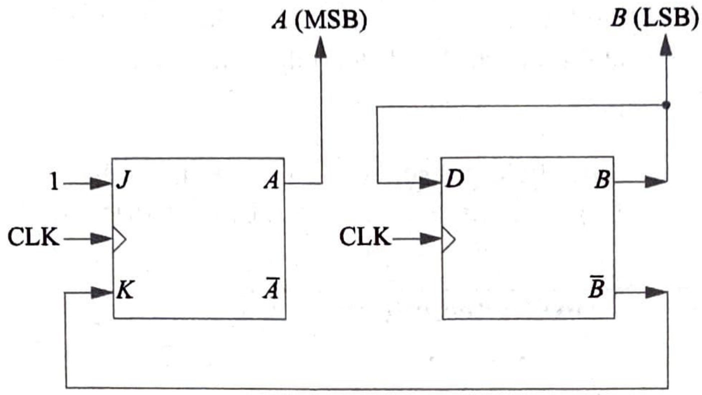
**85.** Consider the following Karnaugh map:

| $AB \backslash CD$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 1 | | | 1 |
| 01 | 1 | 1 | 1 | 1 |
| 11 | | | | |
| 10 | 1 | | | 1 |

Which logic function best represents a minimal SOP expression?

- ○ A. $f(A,B,C,D) = \overline{B}\,\overline{D} + \overline{A}\,B + \overline{A}\,\overline{D}$
- ○ B. $f(A,B,C,D) = \overline{A}\,\overline{D} + \overline{A}\,B + A\,\overline{B}\,\overline{D}$
- ○ C. $f(A,B,C,D) = \overline{A}\,\overline{D} + \overline{A}\,B\,\mathrm{D} + A\,\overline{B}\,\overline{D}$
- ○ D. $f(A,B,C,D) = \overline{B}\,\overline{D} + \overline{A}\,B$

**86.** Flip-flops *A* and *B* form a sequential synchronous circuit as shown below.




After the clock pulse, binary count 10 ($A = 1$, $B = 0$) changes to:

- ○ A. 00
- ○ B. 01
- ○ C. 10
- ○ D. 11

**87.** A sequential logic circuit has one input ($x$), one output ($z$), and six states labeled A–F. The circuit is described by the state table shown below. Entries in the two right-hand columns represent the next-state/output-value combination for each present-state condition and input value. For example, if the present state is B and an input $x = 1$ is applied, the next state will be D and the value of $z$ will be 0.

If the circuit is initially in State C and the input sequence $x = 100$ is applied (meaning the first input is 1, the second input is 0, etc.), the output sequence is best described by:

| Present State | Next State/Output Input $x$: 0 | 1 |
|---|---|---|
| A | C/0 | A/0 |
| B | B/1 | D/0 |
| C | D/0 | B/1 |
| D | F/1 | B/1 |
| E | E/1 | F/0 |
| F | F/0 | A/1 |

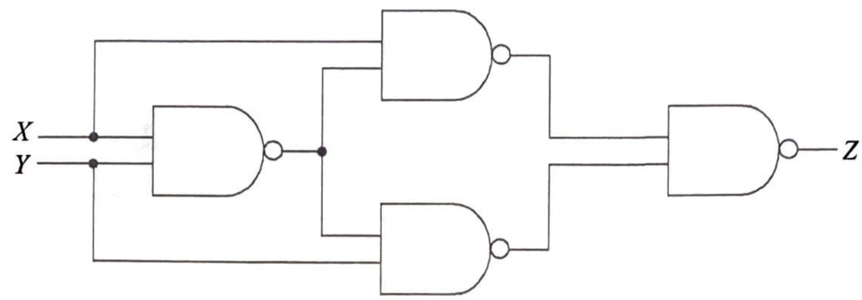
- A. 101
- B. 010
- C. 100
- D. 111

**88.** The Boolean function for $F$ shown in the truth table below is most nearly:

| A | B | C | F |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 0 |

- O A. $\overline{A} + \overline{B}$
- O B. $\overline{B}\overline{A}\overline{C}$
- O C. $B + \overline{A}\overline{C}$
- O D. $\overline{B} + \overline{A}\overline{C}$

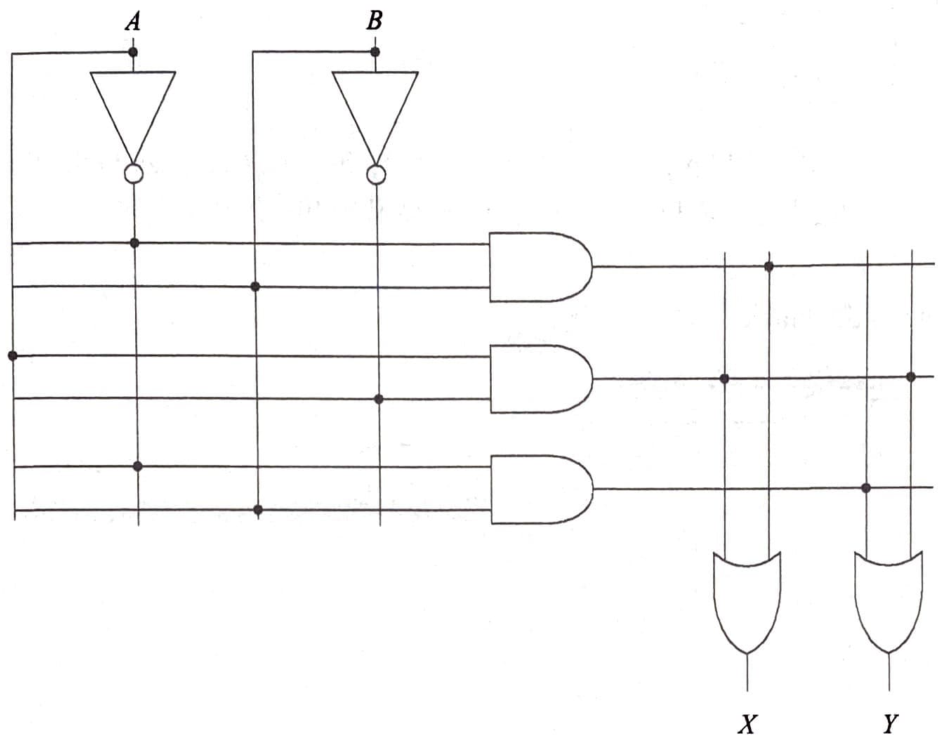
**89.** The Boolean function for the output $Z$ of the circuit shown in the figure is most nearly:




- ○ A. $XY$
- ○ B. $\overline{X}\,\overline{Y}$
- ○ C. $X \oplus Y$
- ○ D. $\overline{X \oplus Y}$

**90.** Given the programming diagram below for a PLD, what is the logic implemented at Output *X*?

- A. $AB + \overline{A}\overline{B}$
- B. $A\overline{B} + \overline{A}B$
- C. $A\overline{B}$
- D. $\overline{A}B$



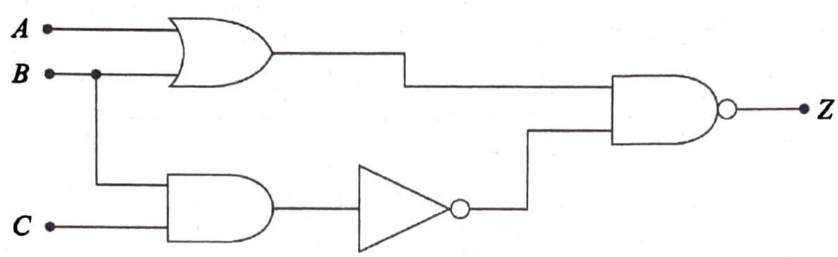
91. Propagation delay times $t_{PLH}$ and $t_{PHL}$ designate the delay for the state of a gate to change from low to high and high to low, respectively. For the circuit below, the delays for the gates are as follows:

| | $t_{PLH}$ (ns) | $t_{PHL}$ (ns) |
|---|---|---|
| AND | 25 | 21 |
| NAND | 20 | 16 |
| OR | 24 | 20 |
| NOT | 10 | 10 |

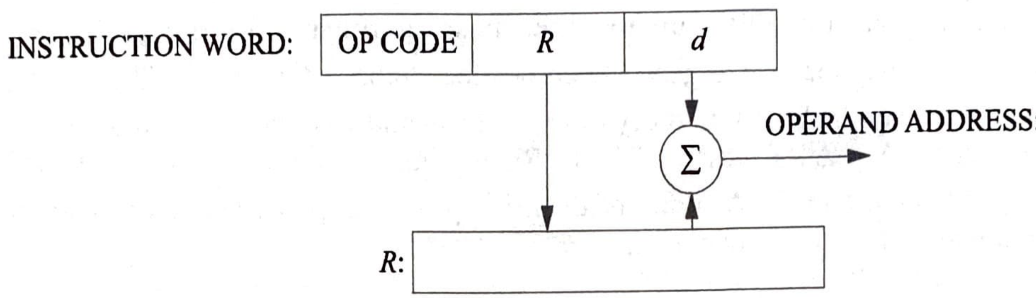
If all of the inputs are initially held high, $A = 1$, $B = 1$, $C = 1$, the time (ns) it will take for the signal to propagate through to Output $Z$ if Input $C$ is changed from 1 to 0 at time $t = 0$ is

__________.

Enter your response in the blank.



**92.** When a CPU fetches an instruction word from memory, the word contains an operation code (op code) that indicates the type of operation the CPU is to perform and information specifying where the instruction operands are located. A computer may use various addressing modes to specify the operand location. One such addressing mode is shown below, where *R* designates some register within the CPU and *d* is a constant embedded in the instruction word.




Which of the following terms best describes the addressing mode used by the instruction above?

○ A. Immediate addressing
○ B. Direct addressing
○ C. Indexed addressing
○ D. Indirect addressing

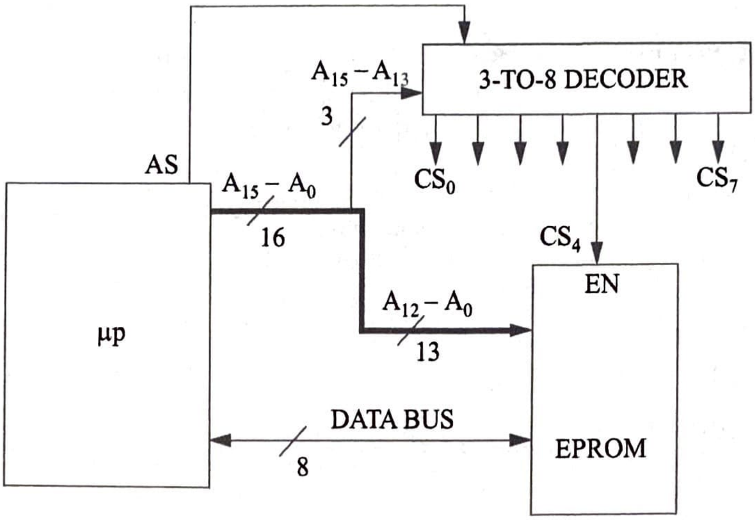
**93.** A microprocessor (μp) uses a 16-bit address bus and an 8-bit data bus. The address bus lines are labeled $A_{15}$ to $A_0$, where $A_{15}$ is the most significant address bit and $A_0$ is the least significant address bit. The microprocessor generates an active-low address strobe (AS) at the beginning of each memory access cycle to indicate that a valid address has been placed on the address bus. The AS signal is asserted for the entire memory access cycle.

In a certain application of the μp, the three most significant address bits ($A_{15}$–$A_{13}$) are used as inputs to a 3-of-8 decoder to generate chip-select signals ($CS_0$–$CS_7$). The chip-select signals are used to enable an EPROM memory device whose address lines are tied directly to the lower 13 address lines ($A_{12}$–$A_0$) of the μp. The EPROM's output lines are enabled whenever its enable input (EN) is pulled low. A figure of the microprocessor described above and the decoder truth table are shown on the opposite page.

The range of addresses (expressed in hexadecimal) to which the EPROM in the figure will respond is most nearly:

- ○ A. 0000 to 1FFF
- ○ B. 4000 to 5FFF
- ○ C. 8000 to 9FFF
- ○ D. E000 to FFFF

**93. (Continued)**




**Decoder Truth Table**

| AS | $A_{15}$ | $A_{14}$ | $A_{13}$ | $CS_0$ | $CS_1$ | $CS_2$ | $CS_3$ | $CS_4$ | $CS_5$ | $CS_6$ | $CS_7$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | X | X | X | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |

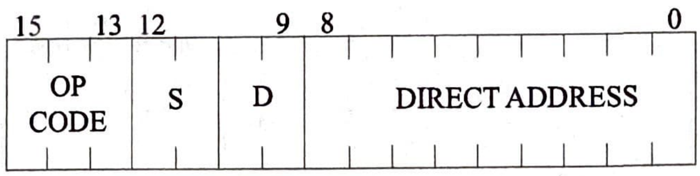
X = "don't care"





NEXT→

**94.** A microprocessor uses the instruction format shown for instructions that use a direct address. The amount of memory that can be accessed using direct address mode is most nearly:




S specifies the source register
D specifies the destination register

- ○ A. 256 words
- ○ B. 512 words
- ○ C. 1,024 words
- ○ D. 2,048 words

**95.** A microprocessor has three 16-bit registers—D1, D2, and D3—with the initial values shown below in hexadecimal:

D1: 0123
D2: 4567
D3: 89AB

The registers are pushed onto the stack and immediately popped off in the following sequence:

PUSH D1
PUSH D2
PUSH D3
POP D1
POP D2
POP D3

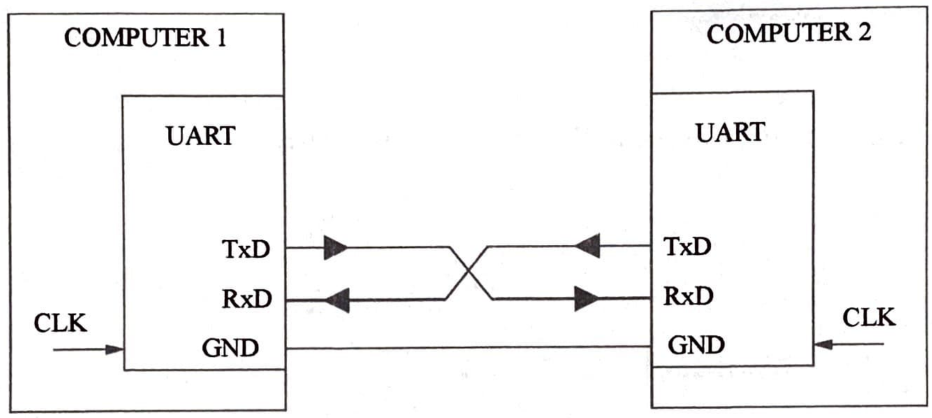
The value in D1 after the operations are performed is most nearly:

- ○ A. 0123
- ○ B. 4567
- ○ C. 89AB
- ○ D. 2301

**96.** The figure below shows how two computers communicate with each other. The interface between the two computers represents which of the following types of communication systems?

Select **all** that apply.

- ☐ A. Full duplex
- ☐ B. Half duplex
- ☐ C. Simplex
- ☐ D. Parallel
- ☐ E. Serial

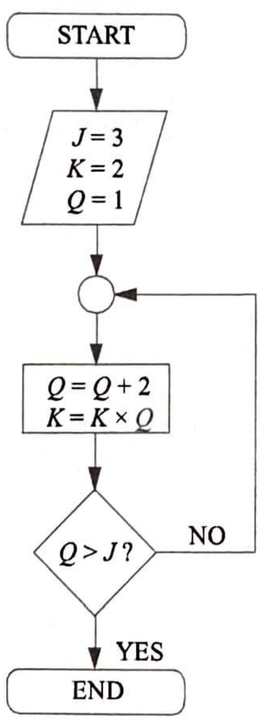


**97.** The following function counts down starting at $Y$. What number does the countdown return if it is called with $Y = 10$?

```
integer function countdown (Y)
        do
            Y = Y – 1
        while (Y > 0)
        return Y
```

- ○ A. –1
- ○ B. 0
- ○ C. 1
- ○ D. 10

**98.** The final value of $Q$ in the following flowchart is most nearly:




- ○ A. 0
- ○ B. 1
- ○ C. 3
- ○ D. 5

**99.** The following pseudocode, which has a worst-case timing of $O(n^2)$, is what type of classical sort algorithm?

```
procedure Sort( listA[]:integer)
  n:integer
  swapped:boolean

  --size(A) – returns the size of array A as an integer
  n = size(listA)
  do
     swapped = false
     for i = 1 to n-1 do
        -- if this pair is out of order
        if listA [i-1] > listA [i] then
           -- swap them and remember something changed
           swap(listA [i-1], listA [i] )
           swapped = true
        end if
     end for
  while (swapped == true)
end procedure
```

- O A. Bubble sort
- O B. Insertion sort
- O C. Merge sort
- O D. Quick sort

**100.** Given a complete binary search tree consisting of 15 elements, the height of the tree is:

- O A. 15
- O B. 8
- O C. 7
- O D. 3

# SOLUTIONS

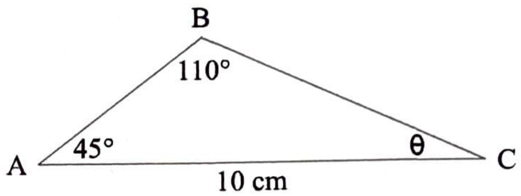
# FE ELECTRICAL AND COMPUTER SOLUTIONS

Detailed solutions for each question begin on the next page.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | A | 26 | 4.6–5.0 | 51 | A | 76 | C |
| 2 | D | 27 | B | 52 | B | 77 | D |
| 3 | A, D | 28 | A | 53 | A | 78 | B |
| 4 | A | 29 | B | 54 | C | 79 | C |
| 5 | B | 30 | A | 55 | B | 80 | C |
| 6 | D | 31 | A | 56 | B | 81 | A, B, D |
| 7 | D | 32 | C | 57 | A | 82 | C |
| 8 | D | 33 | 8 | 58 | A | 83 | C |
| 9 | A | 34 | C | 59 | C | 84 | B |
| 10 | C | 35 | B | 60 | A | 85 | D |
| 11 | A | 36 | A | 61 | see solution | 86 | A |
| 12 | C | 37 | see solution | 62 | D | 87 | D |
| 13 | A | 38 | B | 63 | 207–209 | 88 | D |
| 14 | B | 39 | A | 64 | B | 89 | C |
| 15 | see solution | 40 | D | 65 | B | 90 | B |
| 16 | A | 41 | B | 66 | C | 91 | 47 |
| 17 | A | 42 | A | 67 | D | 92 | C |
| 18 | B | 43 | D | 68 | D | 93 | C |
| 19 | C | 44 | B | 69 | A | 94 | B |
| 20 | C | 45 | D | 70 | B | 95 | C |
| 21 | A | 46 | A | 71 | A | 96 | A, E |
| 22 | D | 47 | C | 72 | D | 97 | B |
| 23 | B | 48 | B | 73 | see solution | 98 | D |
| 24 | B | 49 | C | 74 | D | 99 | A |
| 25 | C | 50 | C | 75 | A | 100 | D |

1. Refer to the Law of Sines equation in the Mathematics chapter of the *FE Reference Handbook.*

$\theta = 180 - 110 - 45 = 25°$




Law of Sines:

$$\frac{10}{\sin 110°} = \frac{AB}{\sin 25°}$$

AB = 4.497 cm

**THE CORRECT ANSWER IS: A**

2. Refer to the Algebra of Complex Numbers section in the Mathematics chapter of the *FE Reference Handbook.*

$$\frac{(1-i)^2}{(1+i)^2} = \frac{1-2i+i^2}{1+2i+i^2} = \frac{1-1-2i}{1-1+2i} = \frac{-i}{i} = -1$$

**THE CORRECT ANSWER IS: D**

3. The definitions of injective, surjective, and bijective functions are given in the Discrete Math section in the Mathematics chapter of the *FE Reference Handbook.*

Since no element of B is a function of more than a single element of A, there is a one-to-one (i.e., injective) relationship from A to B. $f(x)$ cannot be surjective since at least one element of B does not map from any element of A. Since it cannot be surjective, it is, by definition, not bijective. Since there is a one-to-one mapping from A to B, the inverse of $f(x)$, or $f^{-1}(x)$, maps B to A. The function is a valid general function since no element of A maps to more than one element of B.

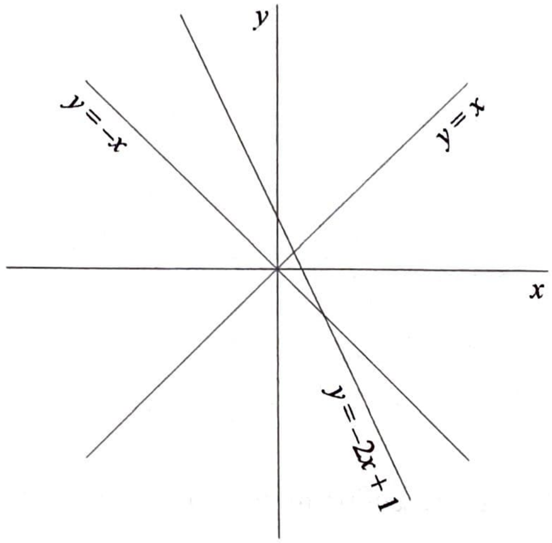
**THE CORRECT ANSWERS ARE: A, D**

4. Refer to the Straight Line section in the Mathematics chapter of the *FE Reference Handbook.*

$y = -x$

$y = x$

$y = -2x + 1$




From graph one, the intersection is at (0, 0), so Options C and D are incorrect.
Also, the second intersection is at (1, –1), so the vertices are at (0, 0), $\left(\frac{1}{3}, \frac{1}{3}\right)$, (1, –1).

**THE CORRECT ANSWER IS: A**

5. Refer to the Test for a Point of Inflection section in the Mathematics chapter of the *FE Reference Handbook.*

$f(x) = x^3 + x^2 - 3$

$f'(x) = 3x^2 + 2x$

$f''(x) = 6x + 2$
$6x + 2 = 0$
$x = -1/3$

$f''(x)$ negative below $x = -1/3$
$f''(x)$ positive above $x = -1/3$

Since $f''(x) = 0$ and $f''(x)$ changes sign at $x = -1/3$, the inflection point is at $x = -1/3$.

**THE CORRECT ANSWER IS: B**

6. Refer to the Partial Derivative section in the Mathematics chapter of the *FE Reference Handbook.*

$$\frac{\partial f}{\partial y} = \frac{\partial(x^2)}{\partial y} + \frac{\partial(xy)}{\partial y} + \frac{\partial(y^2)}{\partial y}$$
$$= 0 + x + 2y$$
$$= x + 2y$$

**THE CORRECT ANSWER IS: D**

7. $$\frac{d^2y}{dt^2} + 6\frac{dy}{dt} + 25y = x(t)$$

The characteristic equation is $D^2 + 6D + 25 = 0$

Referring to the Second-Order Linear Homogeneous Differential Equations with Constant Coefficients section in the Mathematics chapter of the *FE Reference Handbook*:

$a = 6$
$a^2 = 36$
$b = 25$
$4b = 100$

Since $a^2 = 36$ is less than $4b = 100$, the system is underdamped.

**THE CORRECT ANSWER IS: D**

8. Refer to the Differential Equations section in the Mathematics chapter of the *FE Reference Handbook*. The characteristic equation for a second-order linear homogeneous differential equation is:

$$r^2 + ar + b = 0$$

In this problem, $a = 4$ and $b = 4$

$$r^2 + 4r + 4 = 0$$

In solving the characteristic equation, it is noted that there are repeated real roots: $r_1 = r_2 = -2$

Because $a^2 = 4b$, the solution for this critically damped system is:

$$y(x) = (C_1 + C_2x)\, e^{-2x}$$

**THE CORRECT ANSWER IS: D**

9. Refer to the Resolution of a Force section in the Statics chapter of the *FE Reference Handbook.*

$$R_x = \sum F_{xi}, \qquad R_y = \sum F_{yi}, \quad i = 1,2,3$$

$$R_x = 2.12 + 5 \cos 105° = 2.12 - 1.29 = 0.83$$

$$R_y = 2.12 + 5 \sin 105° = 2.12 + 4.83 = 6.95$$

$$R = \sqrt{R_x^2 + R_y^2} = \sqrt{0.83^2 + 6.95^2} = 6.999$$

**THE CORRECT ANSWER IS: A**

**10.** Refer to the Vectors section in the Mathematics chapter of the *FE Reference Handbook.*

The cross product of Vectors **A** and **B** is a vector perpendicular to **A** and **B**.

$$\begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 2 & 4 & 0 \\ 1 & 1 & -1 \end{vmatrix} = \mathbf{i}(-4) - \mathbf{j}(-2-0) + \mathbf{k}(2-4) = -4\mathbf{i} + 2\mathbf{j} - 2\mathbf{k}$$

To obtain a unit vector, divide by the magnitude.

$$\text{Magnitude} = \sqrt{(-4)^2 + 2^2 + (-2)^2} = \sqrt{24} = 2\sqrt{6}$$

$$\frac{-4\mathbf{i} + 2\mathbf{j} - 2\mathbf{k}}{2\sqrt{6}} = \frac{-2\mathbf{i} + \mathbf{j} - \mathbf{k}}{\sqrt{6}}$$

**THE CORRECT ANSWER IS: C**

**11.** Refer to the Matrices section in the Mathematics chapter of the *FE Reference Handbook.*

$$A^{-1} = \frac{\text{adj}(A)}{|A|}$$

$A$ has no inverse when $|A| = 0$.

$$|A| = (2)(K) - (-3)(4) = 0; K = -6$$

**THE CORRECT ANSWER IS: A**

**12.** From the Dispersion, Mean, Median, and Mode Values section in the Engineering Probability and Statistics chapter of the *FE Reference Handbook*:

There are eight measurements. The fourth and fifth measurements are 11 and 12. Since the number of items (eight) is even, the median is the average of the fourth and fifth measurements.

$$\text{Median} = \frac{11+12}{2} = 11.5$$

**THE CORRECT ANSWER IS: C**

**13.** Calculate distance from mean:

$$8 - 15.5 = 7.5$$

Determine how many standard deviations distance represents:

$$\frac{7.5}{2.5} = 3 \text{ standard deviations}$$

From the Unit Normal Distribution table in the Engineering Probability and Statistics chapter of the *FE Reference Handbook.*

For $x = 3$, $R(x) = 0.0013$

**THE CORRECT ANSWER IS: A**

**14.** Refer to the Engineering Probability and Statistics chapter of the *FE Reference Handbook.*

Binomial distribution
$p = 0.5$ (chance of getting a head)
$q = 0.5$ (chance of not getting a head)
$n = 10$ (number of trials)
$x = 4$ (number of heads)

$$P_{10}(4) = \frac{10!}{4!6!}(0.5^4)(0.5^6) = \frac{(10)(9)(8)(7)}{(4)(3)(2)(1)}(0.5)^{10}$$

$$= 0.2051$$

**THE CORRECT ANSWER IS: B**

**15.** Refer to the economic decision trees in the Engineering Economics chapter of the *FE Reference Handbook.*

Expected value of Project B = (0.65)($1,250,000) = $812,500 (lowest payoff)

Expected value of Project A = (0.4)($3,500,000) = $1,400,000

Expected value of Project C = (0.75)($2,750,000) = $2,062,500 (highest payoff)

**THE CORRECT ANSWERS ARE SHOWN ABOVE.**

**16.** Refer to the NCEES Rules of Professional Conduct, Section B, in the Ethics and Professional Practice chapter of the *FE Reference Handbook.*

**THE CORRECT ANSWER IS: A**

**17.** Examinees are expected to be familiar with concepts of common mode and differential mode voltages.

Point A has the highest risk. If the person is in contact with the ground, then the differential voltage applied to the person at Point A is the highest. Point B is grounded and has the lowest differential voltage. The transformer is ideal, and the load is floating. A fault condition does not exist. Thus, there is no differential voltage to ground at Point C or Point D.

**THE CORRECT ANSWER IS: A**

**18.** Refer to the NCEES Rules of Professional Conduct section in the Ethics and Professional Practice chapter of the *FE Reference Handbook.*

**THE CORRECT ANSWER IS: B**

**19.** Refer to the Ethics and Professional Practice chapter of the *FE Reference Handbook.* Section B in the Rules of Professional Conduct states:

"Licensees shall undertake assignments only when qualified by education or experience in the specific technical fields of engineering or surveying involved."

**THE CORRECT ANSWER IS: C**

**20.** Refer to the Non-Annual Compounding section in the Engineering Economics chapter of the *FE Reference Handbook.* Use the non-annual compounding interest equation:

$$i_e = \left(1+\frac{r}{m}\right)^m - 1$$

$$r = 0.17 \; m = 4$$

$$i_e = \left(1+\frac{0.17}{4}\right)^4 - 1$$

$$= 0.1815$$

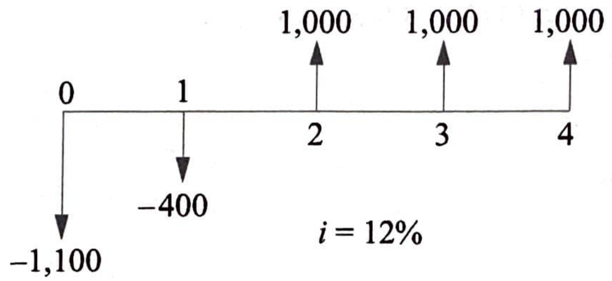
**THE CORRECT ANSWER IS: C**

**21.** Refer to the table of equations in the Engineering Economics chapter of the *FE Reference Handbook.*

Annual cost: $= \$900(A/P, 8\%, 5) + \$50 - \$300(A/F, 8\%, 5)$
$= \$900(0.2505) + \$50 - \$300(0.1705)$
$= \$225.45 + \$50 - \$51.15$
$= \$224.30$

**THE CORRECT ANSWER IS: A**

**22.** Refer to the table of equations in the Engineering Economics chapter of the *FE Reference Handbook.*




$$P = -1{,}100 - 400\,(P/F,\ 12\%,\ 1) + 1{,}000\,(P/F,\ 12\%,\ 2) + 1{,}000\,(P/F,\ 12\%,\ 3) + 1{,}000\,(P/F,\ 12\%,\ 4)$$

$$= -1{,}100 - 400\,(0.8929) + 1{,}000\,(0.7972) + 1{,}000\,(0.7118) + 1{,}000\,(0.6355)$$

$$= 687.34$$

$$A = P\,(A/P,\ 12\%,\ 4) = 687.34(0.3292)$$

$$= \$226 \text{ per year}$$

**THE CORRECT ANSWER IS: D**

**23.** Refer to the definition of breakeven analysis in the Engineering Economics chapter of the *FE Reference Handbook.*

**THE CORRECT ANSWER IS: B**

**24.** From the Safety and Prevention section in the Safety chapter of the *FE Reference Handbook*:

Risk = Hazard × Probability

Risk (fatalities/year) = 5,000 miles × 0.001 incidents/mile × 0.05 contacts/incident × 0.5 fatalities/contact = 0.125 fatalities/year

**THE CORRECT ANSWER IS: B**

**25.** Refer to the Resistivity section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

Since the current density is 100 A/m$^2$, the current in the conductor is given by:

$I = 100 \times \text{Area} = 100 \times (\pi r^2) = 100 \times \pi(0.05)^2$

$I = 0.7854\ \text{A}$

The resistance per unit length is given by:

$$R = \frac{\rho L}{A} = \frac{0.1\ \Omega\cdot\text{m} \times L}{\pi(0.05\text{m})^2} = 12.73\ \Omega/\text{m}$$

Since $P = I^2R$, the power loss per unit length is given by:

$$P = (0.785\,\text{A})^2 \times 12.73\,\Omega/\text{m} = 7.854\ \text{W/m}$$

**THE CORRECT ANSWER IS: C**

**26.** From the Solid-State Electronics and Devices section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook*, the contact potential of a p-n junction is:

$$V_o = \frac{kT}{q}\ln\left(\frac{N_a N_d}{n_i^2}\right)$$

Thus, $V_o$ is proportional to temperature in Kelvin.

From the Units and Conversion Factors chapter of the *FE Reference Handbook*:

°C = (°F – 32)/1.8

K = °C + 273.15

Thus, K = (°F – 32)/1.8 + 273.15

At 80°F = 299.8167 K

At 180°F = 355.3722 K

Thus, at 180°F, $V_o$ = 0.026 × (355.3722/299.8167) = 0.030818

Increase is 0.030818 – 0.026 = 4.8 mV

**THE CORRECT RANGE OF ANSWERS IS: 4.6–5.0**

27. From the Resistivity section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook*, there is a linear relationship between resistivity and temperature for metals such as copper according to the following relationship:

$$\rho = \rho_0 \, [1 + \alpha(T - T_0)]$$

where $\alpha$ is the temperature coefficient of resistivity per degree, $\rho_0$ is the resistivity at $T_0$, $T$ is for temperature in °C, and $\rho$ is the resistivity of the material.

$$\begin{aligned}\rho &= 10[1 + 0.004041(30 - 20)] \\ &= 10.04\ \Omega\cdot\text{m}\end{aligned}$$

**THE CORRECT ANSWER IS: B**

28. Refer to the Resistivity section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook*.

$$R = R_0\left[1+\alpha\left(T - T_0\right)\right]$$

$$\alpha = \frac{R - R_0}{R_0\left(T - T_0\right)} = \frac{300 - 200}{200\left(125 - 0\right)} = 0.004$$

**THE CORRECT ANSWER IS: A**

29. Refer to the Power Absorbed by a Resistive Element section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook*.

The power dissipated in a resistor can be found by applying the equation $P = \dfrac{V^2}{R}$.

The voltage across the 90-Ω resistor is 100 – 60 = 40 V. Therefore, $P = \dfrac{40^2}{90\ \Omega} = 17.78\ \text{W}$

**THE CORRECT ANSWER IS: B**

**30.** Refer to the Kirchhoff's Laws section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

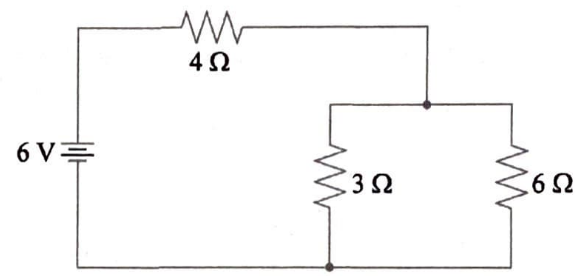
Apply KCL to the node marked $V_0$:

$$\frac{1}{3}(V_0-36)+\frac{1}{6}V_0+\frac{1}{6}(V_0-6)=0 \Rightarrow V_0=19.5\text{ V}$$

**THE CORRECT ANSWER IS: A**

**31.** Refer to the Resistors in Series and Parallel section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$R_T = 4\ \Omega + 3\ \Omega \parallel 6\ \Omega = 4\ \Omega + 2\ \Omega$

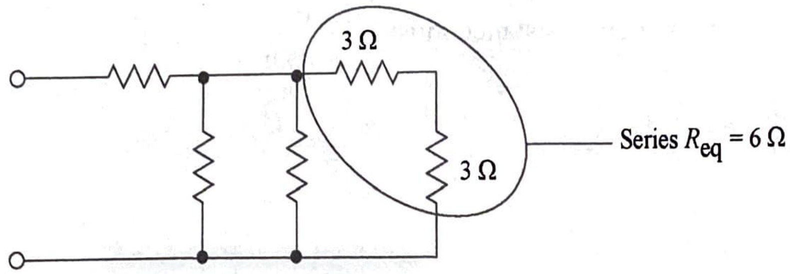


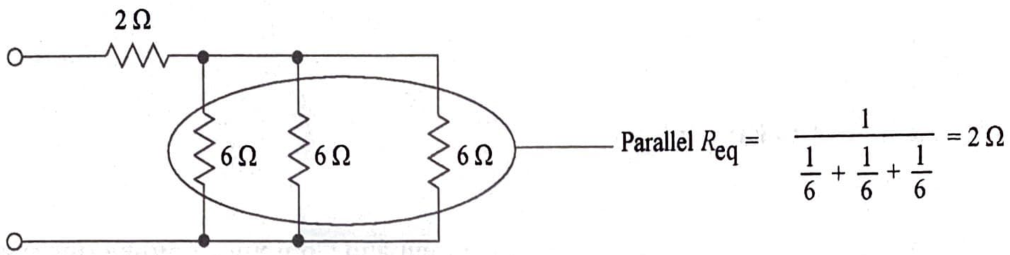

$$R_T = 6\ \Omega \Rightarrow I_T = \frac{6\text{ V}}{6\ \Omega} = 1\text{ A}$$

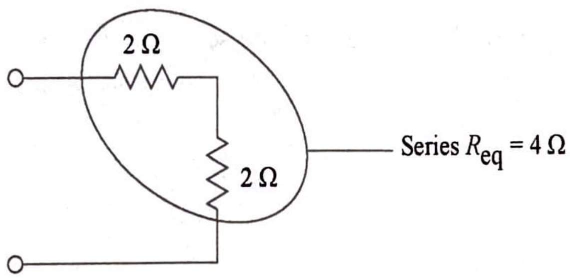
$$I_x = \frac{3}{9}(I_T) = \frac{1}{3}\text{ A}$$

**THE CORRECT ANSWER IS: A**

**32.** Refer to the Resistors in Series and Parallel section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*




**THE CORRECT ANSWER IS: C**

**33.** Refer to the Resistors in Series and Parallel section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

If $i_1 = 1.25$ mA, then the total equivalent resistance must be $\dfrac{10\text{ V}}{1.25\text{ mA}} = 8\text{ k}\Omega$

$$4{,}000 + \frac{R(4{,}000 + 4{,}000)}{R + 4{,}000 + 4{,}000} = 8{,}000\ \Omega$$

$$\frac{8{,}000R}{8{,}000 + R} = 4{,}000\ \Omega$$

$$8{,}000R = 4{,}000R + 32\text{ M}\Omega$$

$$R = 32\text{ M}\Omega/4\text{ k}\Omega$$

$$= 8\text{ k}\Omega$$

**THE CORRECT ANSWER IS: 8**

**34.** Refer to the Source Equivalents section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$R_N$ is the total resistance seen at the load end with the voltage source set equal to zero (replaced by short circuit).

$R_N = 60\ \Omega + (50\ \Omega$ in parallel with $200\ \Omega)$

$R_N = 60 + 40 = 100\ \Omega$

**THE CORRECT ANSWER IS: C**

**35.** Refer to the Source Equivalents section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

With the 12-V source replaced with a short circuit, $R_{Th} = 8 + 12 \parallel 6 = 8 + 4 = 12\ \Omega$

**Alternate Solution:**

$$R_{eq} = \frac{V_{oc}}{I_{sc}}$$

$$V_{oc} = 12 \cdot \left(\frac{12}{6+12}\right) = 8$$

$$I_{sc} = \frac{12}{6 + \left(\frac{8 \cdot 12}{8+12}\right)} \cdot \left(\frac{12}{8+12}\right) = 0.666$$

$$R_{eq} = \frac{8}{0.666} = 12\ \Omega$$

**THE CORRECT ANSWER IS: B**

**36.** Refer to the Effective or RMS Values section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$$X_{rms} = \sqrt{X_{dc}^2 + \sum_{n=1}^{\infty} X_n{}^2}$$

$$\text{for } i_1, X_{rms} = \sqrt{0^2 + \left[\left(\frac{10}{\sqrt{2}}\right)^2 + \left(\frac{-7}{\sqrt{2}}\right)^2 + \left(\frac{-3}{\sqrt{2}}\right)^2\right]} = 8.89$$

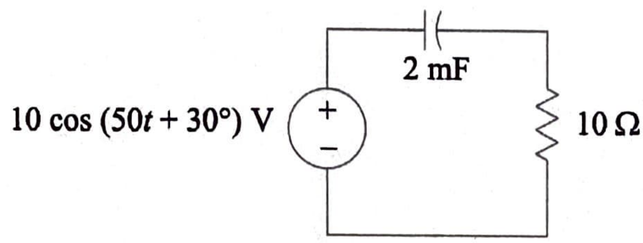
$$\text{for } i_2, X_{rms} = \sqrt{0^2 + \left[\left(\frac{10}{\sqrt{2}}\right)^2 + \left(\frac{3}{\sqrt{2}}\right)^2 + \left(\frac{7}{\sqrt{2}}\right)^2\right]} = 8.89$$

Thus both waveforms have the same rms value.

**THE CORRECT ANSWER IS: A**

37. Refer to the Phasor Transforms of Sinusoids section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

Time domain:



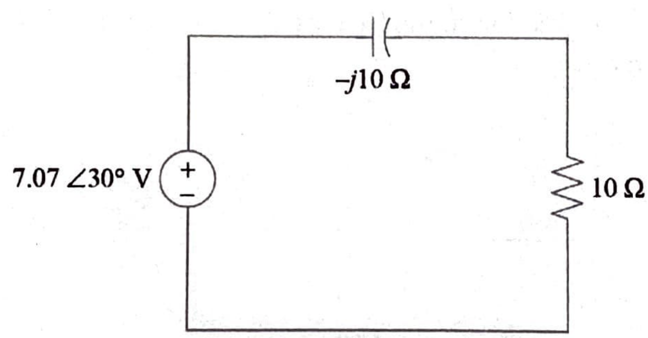

From the sinusoidal source, $\omega = 50$ rad/s

$$Z_C = \frac{1}{j\omega C} = -j\frac{1}{50(0.002)} = -j10\ \Omega$$

$$Z_R = R = 10\ \Omega$$

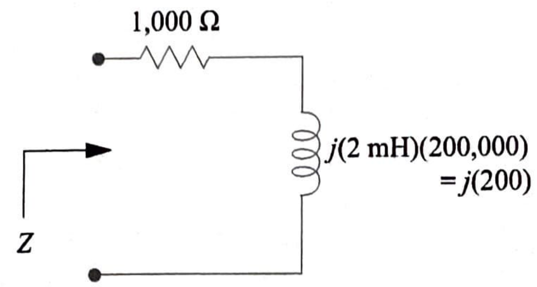
$$V_S = V_{rms}\angle\phi = 7.07\angle 30°\ V$$

∴ in Frequency (Phasor) domain




**THE CORRECT ANSWER IS SHOWN ABOVE.**

**38.** Refer to the Phasor Transforms of Sinusoids section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

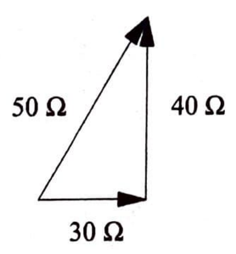



The impedance of the resistor is $Z_R = R = 1{,}000\ \Omega$.
The impedance of the inductor is $Z_L = j\omega L = j(100{,}000)(0.002) = j200\ \Omega$
Since they are in series, $Z = 1{,}000 + j200\ \Omega$

**THE CORRECT ANSWER IS: B**

**39.** Refer to the Phasor Transforms of Sinusoids section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$Z = 30 + j90 - j50 = 30 + j40\ \Omega$




**THE CORRECT ANSWER IS: A**

**40.** Refer to the RC and RL Transients section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

After a long time, $v_c = 60 \times \dfrac{2}{2+1} = 40 \text{ V}$

After $t = 0^+$,

$$v_c(t) = v_c(0)e^{\frac{-t}{RC}}$$

$$RC = 5 \text{ k}\Omega \times 10\ \mu\text{F} = 5{,}000 \times 10^{-5} = 0.05$$

$$v_c(t) = 40\ e^{\frac{-t}{0.05}} = 40\ e^{-20t}$$

**THE CORRECT ANSWER IS: D**

**41.** Refer to the Resonance section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$v_o$ will be maximum when $L$ and $C$ are in parallel resonance.

$$\omega_o = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{\left(0.5 \times 10^{-6}\right)\left(5 \times 10^{-3}\right)}} = \frac{1}{\sqrt{25 \times 10^{-10}}}$$

$$= \frac{10^5}{5} = 2 \times 10^4 \text{ rad/s} \qquad f_o = \frac{20 \times 10^3}{2\pi} = 3.18 \text{ kHz}$$

**THE CORRECT ANSWER IS: B**

**42.** Refer to the Control Systems section in the Instrumentation, Measurement, and Control chapter of the *FE Reference Handbook.*

$$\mathbf{Z}_{\text{in}} = \frac{V_i}{I_i} = R_1 + \frac{1}{sC_1} + \frac{\frac{R_2}{sC_2}}{R_2 + \frac{1}{sC_2}}$$

$$= \frac{sR_1C_1 + 1}{sC_1} + \frac{R_2}{sR_2C_2 + 1}$$

$$= \frac{(sR_1C_1 + 1)(sR_2C_2 + 1) + sR_2C_1}{R_2C_1C_2\left[s\left(s + \frac{1}{R_2C_2}\right)\right]}$$

Poles at $s = 0; s = -\frac{1}{R_2C_2}$

**THE CORRECT ANSWER IS: A**

**43.** Refer to the Laplace Transforms section in the Mathematics chapter of the *FE Reference Handbook.*

$$V_{\text{out}}(s) = \frac{1.2(s+2)}{(s+1)(s+4)}\left(\frac{1}{s}\right)$$

Applying the final value theorem to this, we multiply by $s$, which cancels $s$ in the denominator.

Evaluate $\frac{V_{\text{out}}}{V_{\text{in}}}$ at $s = 0 \Rightarrow \frac{1.2 \times 2}{4} = 0.6 \Rightarrow v_{\text{out}}(\infty) = 0.6(1) = 0.6 \text{ V}$

Alternatively, by inspection of the circuit with each capacitance replaced with an open circuit:

$$\frac{30}{30+20} = 0.6 \text{ V}$$

**THE CORRECT ANSWER IS: D**

**44.** Refer to the Laplace Transforms section in the Mathematics chapter of the *FE Reference Handbook.*

$$\lim_{t\to\infty} f(t) = \lim_{s\to 0} sF(s) = \lim_{s\to 0} s\frac{3}{s^2+4s} = \lim_{s\to 0}\frac{3}{s+4} = \frac{3}{4} = 0.75$$

**THE CORRECT ANSWER IS: B**

**45.** Refer to the z-Transforms section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$$y[k] = \frac{1}{6}\left(3x[k] + 2x[k-1] + x[k-2]\right)$$

Taking the $z$-transform of both sides yields:

$$Y(z) = \frac{1}{6}\left[3X(z) + 2z^{-1}X(z) + z^{-2}X(z)\right] = \frac{X(z)}{6}\left[3 + 2z^{-1} + z^{-2}\right] = \frac{X(z)}{6}\left[\frac{3z^2+2z+1}{z^2}\right]$$

$$H(z) = \frac{Y(z)}{X(z)} = \frac{1}{6}\left[\frac{3z^2+2z+1}{z^2}\right]$$

**THE CORRECT ANSWER IS: D**

**46.** Refer to the Communication Theory and Concepts section of the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

The value of the integral is:

$$\int_{-\infty}^{\infty} \cos(2t)\,\delta(t-1)\,dt = \cos(2) = -0.4161.$$

**THE CORRECT ANSWER IS: A**

**47.** Refer to the Sampling section in the Instrumentation, Measurement, and Control chapter of the *FE Reference Handbook.*

Determine the maximum expected tachometer frequency. First, calculate the circumference of the wheel: $C = \pi \times D$, so $C = 75.4$ in.

After appropriate unit conversion, compute the maximum expected square wave frequency of the tachometer signal:

$$\frac{100[\text{miles/hr}] \times 5{,}280[\text{ft/mile}] \times 12[\text{in./ft}]}{75.4[\text{in./pulse}] \times 60[\text{min/hr}] \times 60[\text{sec/min}]}$$

The maximum expected tachometer signal frequency is approximately 23.3 Hz.

The tenth harmonic is $10 \times 23.3 = 233$ Hz. The minimum sample rate would be roughly 467 Hz.

**THE CORRECT ANSWER IS: C**

**48.** Refer to the Analog Filter Circuits section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$$|H(j\omega)| = \frac{|j\omega|}{|1 + j\omega|} = \left(\frac{\omega^2}{1+\omega^2}\right)^{1/2}$$

**THE CORRECT ANSWER IS: B**

**49.** Refer to the z-Transforms section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

Taking the $z$-transform of the difference equation gives

$$Y(z) = \frac{1}{2}X(z) + \frac{1}{3}z^{-1}Y(z)$$

This gives the transfer function, $H(z) = \dfrac{Y(z)}{X(z)} = \dfrac{\frac{1}{2}}{1 - \frac{1}{3}z^{-1}}$

The inverse $z$-transform of $H(z)$ is

$$h[n] = \frac{1}{2}\left(\frac{1}{3}\right)^n, \; n \ge 0$$

**THE CORRECT ANSWER IS: C**

**50.** Refer to the table of Depletion MOSFET equations in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$v_{GS} = 1\text{ V}$ and $v_{GD} = 0\text{ V}$ $\Rightarrow v_{DS} = 1\text{ V}$

Since $v_{GS} > V_p$ and $v_{GD} > V_p$
$(1 > -4)$ $(0 > -4)$

the MOSFET operates in the triode region

$\therefore i_D = 0.2[2(1 - (-4))(1) - (1)^2] = 0.2[9] = 1.8\text{ mA}$

**THE CORRECT ANSWER IS: C**

**51.** Refer to the table of JFET equations in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$$i_D = I_{DSS}\left(1 - v_{GS} / V_p\right)^2$$

$$4 = 16\left(1 + \frac{v_{GS}}{4}\right)^2$$

$$\pm 0.5 = \left(1 + \frac{v_{GS}}{4}\right)$$

$$v_{GS} = -2, -6$$

$$-6 < V_p \Rightarrow v_{GS} = -2.0\text{ V}$$

**THE CORRECT ANSWER IS: A**

**52.** Refer to the table of Bipolar Junction Transistor equations in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

For dc bias calculations, all capacitors act like open circuits. The Thévenin equivalent of the base-bias circuit can be represented as shown below:

where, $R_B = R_1 \parallel R_2 = 2\ \text{k}\Omega \parallel 1\ \text{k}\Omega = 667\ \Omega$

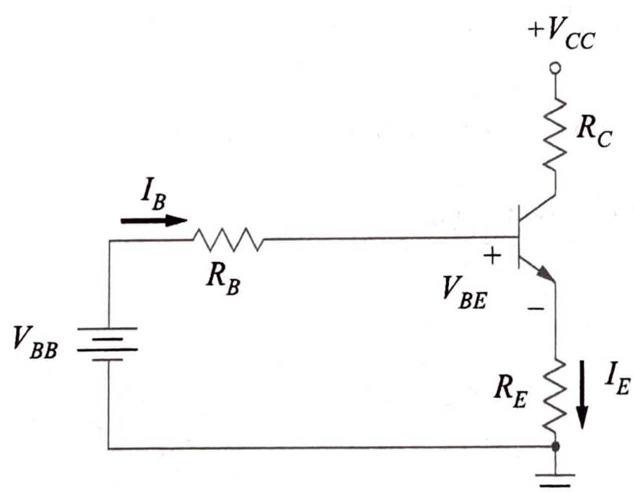
$$V_{BB} = V_{CC}\frac{R_2}{R_1 + R_2} = (30\ \text{V})\left(\frac{1\ \text{k}\Omega}{3\ \text{k}\Omega}\right) = 10\ \text{V}$$

by KVL: $V_{BB} - I_B R_B - V_{BE} - I_E R_E = 0$

Since $I_B = \dfrac{I_E}{\beta + 1}$

$$V_{BB} - \frac{I_E}{\beta+1}R_B - V_{BE} - I_E R_E = 0$$

$$I_C \approx I_E = \frac{V_{BB} - V_{BE}}{R_E + \left(R_B/(\beta+1)\right)} \approx \frac{V_{BB} - V_{BE}}{R_E} = \frac{9.3}{0.5\ \text{k}\Omega} = 18.6\ \text{mA}$$




**THE CORRECT ANSWER IS: B**

**53.** Refer to the table of Bipolar Junction Transistor equations in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

Since β is large, $V_B \simeq \dfrac{20\ \text{k}\Omega}{100\ \text{k}\Omega} \times 10\ \text{V} = 2\ \text{V}$

$V_E = V_B - V_{BE} = 2 - 0.7 = 1.3\ \text{V}$

$\therefore\ I_E = \dfrac{1.3\ \text{V}}{1.3\ \text{k}\Omega} \simeq I_C = 1\ \text{mA}$

$V_c = V_{cc} - I_c R_c = 10\ \text{V} - (1\ \text{mA})(4\ \text{k}\Omega) = 6\ \text{V}$

**THE CORRECT ANSWER IS: A**

**54.** Refer to the Operational Amplifiers section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

With $V_1$ grounded, the circuit is configured as a noninverting amplifier and

$$V_o = \left(1 + \frac{R_2}{R_1}\right) V_n$$

where $V_n$ is the voltage applied to the noninverting terminal of the op amp.

$V_n$ can be found by applying the voltage divider rule:

$$V_n = \frac{R_4}{R_3 + R_4} V_2$$

Combining the two results yields:

$$V_o = \left(1 + \frac{R_2}{R_1}\right)\left(\frac{R_4}{R_3 + R_4}\right) V_2$$

$$\frac{V_o}{V_2} = \left(1 + \frac{200\,\text{k}\Omega}{5\,\text{k}\Omega}\right)\left(\frac{200\,\text{k}\Omega}{5\,\text{k}\Omega + 200\,\text{k}\Omega}\right)$$

$$\frac{V_o}{V_2} = 40$$

**THE CORRECT ANSWER IS: C**

**55.** Refer to the Measurement section of the Instrumentation, Measurement, and Control chapter of the *FE Reference Handbook.*

$$\frac{60\,\text{mV}}{50\text{ thermocouples}} = \frac{1.2\,\text{mV}}{\text{thermocouples}}$$

$$\frac{1.2\,\text{mV}}{45\,\dfrac{\mu\text{V}}{°\text{C}}} = 26.67\,°\text{C temperature difference}$$

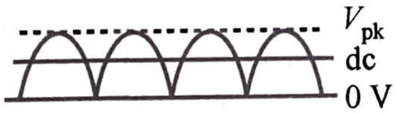
$$T_{\text{hot junc.}} = T_{\text{ref}} + T_{\text{diff}} = 60\,°\text{C} + 26.67\,°\text{C}$$

$$= 86.67\ °\text{C} \Rightarrow \text{approx. } 87$$

**THE CORRECT ANSWER IS: B**

**56.** The I–V characteristic for an ideal diode is shown in the Diodes table in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

The diodes have no voltage drop when forward-biased and conduct no current when reversed-biased, so the voltage across $R_L$ is a series of pulses with the same peak magnitude as the ac source at twice its frequency.




$$P_L = V_{\text{rms}^2}/R_L = \left(V_{pk}/\sqrt{2}\right)^2/R_L = \left(170/\sqrt{2}\right)^2/10 = 1{,}445\text{ W}$$

**THE CORRECT ANSWER IS: B**

**57.** Refer to the AC Machines section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$$n_s = \frac{120f}{p}$$

$$\text{for } p = 2 \Rightarrow n_s = \frac{(120)(60)}{2} = 3{,}600 \text{ rpm}$$

$$\text{for } p = 4 \Rightarrow n_s = \frac{(120)(60)}{4} = 1{,}800 \text{ rpm}$$

$n = (\text{slip})\, n_s \quad$ where $0 < \text{slip} < 1 \Rightarrow n \le n_s$

$n$ is given as $3{,}500 \text{ rpm} \Rightarrow p = 2$

**THE CORRECT ANSWER IS: A**

**58.** Refer to the Complex Power section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$\mathbf{S}_1 = 20\ \angle 36.87° = 16 + j12$ kVA

$\mathbf{S}_2 = 10\ \angle{-53.13°} = 6 - j8$ kVA

$\mathbf{S} = \mathbf{S}_1 + \mathbf{S}_2 = (16 + j12) + (6 - j8)$

$\mathbf{S} = 22 + j4 = P + jQ \Rightarrow Q = 4$ kvar

**THE CORRECT ANSWER IS: A**

**59.** Refer to the Complex Power section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

Complex ac power is expressed as

$\mathbf{S} = P + jQ$, where $P = |\mathbf{S}| \cos \theta$, $Q = |\mathbf{S}| \sin \theta$, and $\theta = \cos^{-1}$ (pf)

The original real and reactive power, then, are given by

$P = 100 \text{ kVA} \times 0.65 = 65 \text{ kW}$ and

$Q = 100 \text{ kVA} \times \sin(\cos^{-1} 0.6) = 76 \text{ kvar}$, inductive

$\mathbf{S}_{\text{original}} = 65 \text{ kW} + j76 \text{ kvar}$

Adding a purely capacitive load will not change the total real power $P$, but it will decrease the reactive power $Q$.

$\mathbf{S}_{\text{NEW}} = 65 \text{ kW} + j(76 - Q_C) \text{ kvar}$

$$\tan(\theta_{\text{new}}) = \tan(\cos^{-1} 0.9) = 0.48 = \frac{76 - Q_C}{65} \Rightarrow Q_C = 44.5 \text{ kvar}$$

**THE CORRECT ANSWER IS: C**

**60.** Examinees are expected to be familiar with the application of Ohm's law to ac circuits.

$Z(\text{Line}) = 2$, $Z(\text{Load}) = 7 + j12$

$V = IZ = I \times [Z(\text{Line}) + Z(\text{Load})]$

$Z = [Z(\text{Line}) + Z(\text{Load})]$

$Z = 2 + 7 + j12 = 9 + j12$ or $= 15 \angle 53.13°$(only need magnitude for these calculations)

$I = V/Z = 120/15 = 8 \text{ A}$

$V(\text{Line Drop}) = IZ = (8) \times (2) = 16 \text{ V}$

**THE CORRECT ANSWER IS: A**

61. Refer to the Complex Power section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

The apparent power consumed by the load is 2 MVA, and the load voltage is 13,800 V. In this single-phase circuit, the magnitude of the transmission line current is:

$I = 2 \times 10^6/13{,}800 = 145$ A

The real power loss in the transmission line is:
$P_{\text{loss}} = I^2 R = (145^2)(3) = 63$ kW

The reactive power loss in the transmission line is:
$Q_{\text{loss}} = I^2 X = (145^2)(10) = 210$ kvar

**THE CORRECT ANSWERS ARE SHOWN ABOVE.**

62. Refer to the Turns Ratio section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$Z_{\text{p}} = a^2 Z_{\text{s}}$

$= 4^2 \times 2 = 16 \times 2 = 32\ \Omega$

**THE CORRECT ANSWER IS: D**

63. Refer to the Balanced Three-Phase (3-$\phi$) Systems section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

On the primary side, each single-phase transformer is connected from line-to-line since the 3-phase transformer primary is connected in delta. Therefore, the voltage across a single-phase transformer winding is 240 V. As a result, the voltage on the secondary side of a single-phase transformer winding is 120 V since the turns ratio is 2:1. The secondary is connected in wye, and thus the voltage of 120 V is from line-to-neutral. The rms value of the line-to-line voltage on the secondary side will be $\sqrt{3} \times 120$ V = 207.84 V.

**THE CORRECT RANGE OF ANSWERS IS: 207–209**

**64.** Refer to the AC Machines and Balanced Three-Phase (3-$\phi$) Systems sections in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

The angular velocity (speed) is $n_s = 120\ f/P = 120 \times 60/2 = 3{,}600$ rpm

The mechanical input power is $P_{\text{in}} = T \times \omega_{\text{m}} = 1{,}000 \times (2\pi/60) \times 3{,}600 = 377$ kW

The output power is: $P_{\text{out}} = P_{\text{in}} - P_{\text{loss}} = 377\text{ kW} - 50\text{ kW} = 327$ kW

The output apparent power is: $|S_{\text{out}}| = P_{\text{out}}/\text{pf} = 327\text{ kW}/0.8 = 409$ kVA

The line current of the armature is: $I_{\text{L}} = |S_{\text{out}}|/(\sqrt{3} \times V_L) = (409\text{ kVA})/(\sqrt{3} \times 480\text{ V}) = 492\text{A}$

**THE CORRECT ANSWER IS: B**

**65.** Refer to the Magnetic Fields section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$$B = \mu H = \frac{\mu I}{2\pi r}$$

$$I = \frac{2\pi r B}{\mu}$$

$$= \frac{(2\pi)(0.5)(1)}{4\pi(10^{-7})}$$

$$= \frac{1}{4(10^{-7})}$$

$$= 2.5 \times 10^6\text{ A}$$

**THE CORRECT ANSWER IS: B**

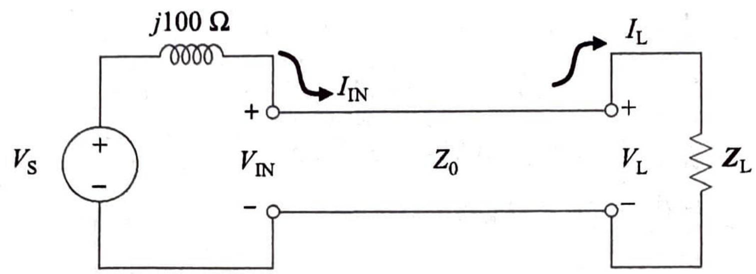
**66.** Refer to the Lossless Transmission Lines section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$$Z_0 = \sqrt{L/C} \Rightarrow (50)^2 = L/C$$

$$\therefore\ L = 2{,}500 \times 133\text{ pF/m} = 0.33\ \mu\text{H/m}$$

**THE CORRECT ANSWER IS: C**

**67.** Refer to the Lossless Transmission Lines section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook*.




For a matched lossless transmission line ($\mathbf{Z}_L = \mathbf{Z}_0$), $V_{IN} = V_L$ and $I_{IN} = I_L$.

$V_{in} = 200\ V_{rms}$

$I_{in} = (200/50) = 4\ A_{rms}$

*KVL* around the loop:

$$-V_S + 4(j\,100) + 200 = 0$$

$$\therefore V_S = 200 + j400$$

$$|V_S|_{rms} = \sqrt{200^2 + 400^2} = 447.2\ V_{rms}$$

**THE CORRECT ANSWER IS: D**

**68.** Using the equations in the item statement:

$$\frac{1\angle 90°}{2.998 \times 10^8} \times 4.518 \times 10^{10} \sqrt{1 - j0.5} = 159.3\angle 76.72° = 36.59 + j155$$

$$e^{-36.59z} = 0.01$$

$$z = \frac{\ln(0.01)}{-36.59} = 0.1259$$

**THE CORRECT ANSWER IS: D**

**69.** Refer to the Decibels and Bode Plots section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

The Bode plot has slopes of 0 dB or –20 dB per decade, so there are simple poles only at $\omega = 10$ rad/s and 1,000 rad/s and a simple zero at $\omega = 100$ rad/s. The only transfer function that satisfies these conditions is Option A.

**THE CORRECT ANSWER IS: A**

**70.** Refer to the Second-Order Control System Models section in the Instrumentation, Measurement, and Control Systems chapter of the *FE Reference Handbook.*

$$\frac{Y(s)}{R(s)} = \frac{K}{s^2 + 2s + 150} = \frac{50}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

$$\therefore\ \omega_n^2 = 150 \text{ and } 2\zeta\omega_n = 2 \Rightarrow \zeta = \frac{2}{2\omega_n} = \frac{1}{\sqrt{150}} = 0.082$$

**THE CORRECT ANSWER IS: B**

**71.** Refer to the Control Systems section in the Instrumentation, Measurement, and Control chapter of the *FE Reference Handbook.*

$$\frac{E(s)}{R(s)} = \frac{1}{1 + GH} = \frac{1}{1 + 10/s(s+5)} = \frac{s(s+5)}{s^2 + 5s + 10}$$

Using the final value theorem and $R(s) = 1/s$:

$$e(t) = \Big|_{t\to\infty} = sE(s)\Big|_{s\to 0} = s\left[\frac{s(s+5)}{s^2+5s+10}\right]\frac{1}{s}\Bigg|_{s\to 0} = \frac{s(s+5)}{s^2+5s+10}\Bigg|_{s\to 0} = 0$$

**THE CORRECT ANSWER IS: A**

72. Refer to the Control Systems section in the Instrumentation, Measurement, and Control chapter of the *FE Reference Handbook.*

The open-loop characteristic equation is:

$D(s) = s^3 + 7s^2 + 14s + 8 = 0$

$(s + 1)(s + 2)(s + 4) = 0$

The open-loop characteristic equation has three poles.

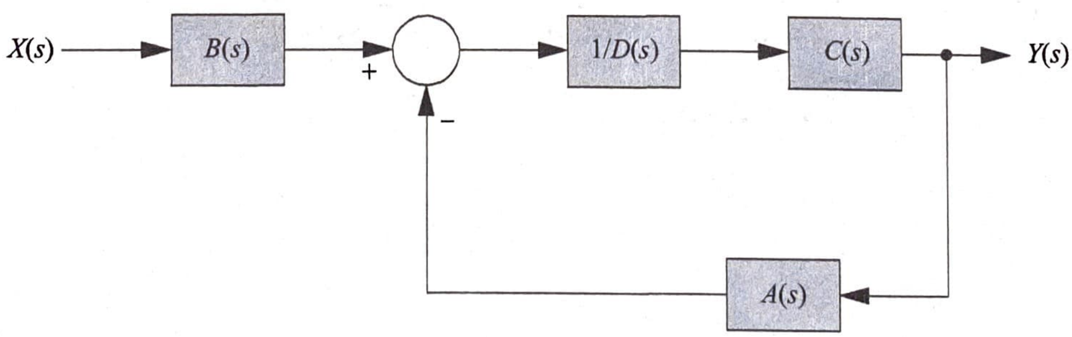
**THE CORRECT ANSWER IS: D**

73. Refer to the Control Systems section in the Instrumentation, Measurement, and Control chapter of the *FE Reference Handbook.*

$$\frac{Y(s)}{X(s)} = \frac{B(s)C(s)}{D(s)+A(s)C(s)} \cdot \frac{\frac{1}{D(s)}}{\frac{1}{D(s)}}$$

$$= \frac{B(s)C(s) \cdot \frac{1}{D(s)}}{1 + A(s)C(s) \cdot \frac{1}{D(s)}}$$

$$= B(s)\left[\frac{C(s) \cdot \frac{1}{D(s)}}{1 + A(s)C(s) \cdot \frac{1}{D(s)}}\right]$$




**THE CORRECT LOCATIONS ARE SHOWN IN THE SHADED AREAS.**

**74.** Refer to the Control Systems section in the Instrumentation, Measurement, and Control chapter of the *FE Reference Handbook.*

Gain margin (GM) is the additional gain required to produce instability in the unity gain feedback control system. That is, if at $\omega = \omega_{180}$,

$\angle G(j\omega_{180}) = -180°$; then

$$GM = -20\log_{10}\left(\left|G\left(j\omega_{180}\right)\right|\right)$$

From the diagrams, when the phase has reached $-180°$, the gain is –50 dB. Therefore the gain margin is found as GM = –(–50 dB) = 50 dB.

**THE CORRECT ANSWER IS: D**

**75.** Refer to the Complex Power section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

The modulated signal, $x(t)$, is given by:

$$x(t) = [1 + 0.8 \sin 50t] \times 2 \sin 1{,}000t = 2 \sin 1{,}000t + 1.6 \sin 50t \sin 1{,}000t$$
$$= 2 \sin 1{,}000t + 0.8[\cos 950t - \cos 1{,}050t]$$

$$P = \frac{V_{rms}^2}{R} \quad \text{and} \quad V_{rms} = \frac{V_{peak}}{\sqrt{2}}$$

$$V_{rms}^2 = \left(\frac{0.8}{\sqrt{2}}\right)^2 = 0.32$$

$$P = \frac{0.32}{R}\,\text{W}$$

The normalized power (into a 1-Ω resistor), then, is 0.32 W.

**THE CORRECT ANSWER IS: A**

**76.** Refer to the Single-Sideband Modulation (SSB) section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

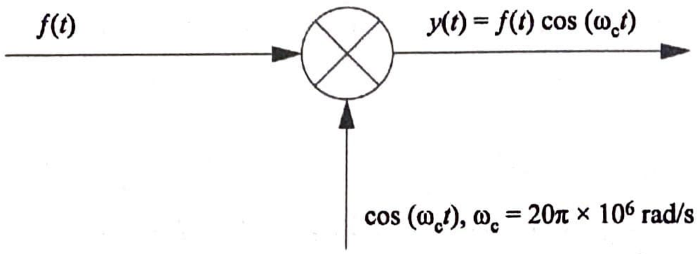
Center frequency $f_c$ = 5,000 + (500 – 20)/2 = 5,240 Hz ≅ 5,250 Hz

Bandwidth BW = 500 – 20 = 480 ≅ 500 Hz

**THE CORRECT ANSWER IS: C**

77. Refer to the Amplitude Modulation (AM) section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*




The input signal $f(t)$ is a square wave with period $T = 1$ ms. The Fourier series expansion of $f(t)$ is given by:

$$f(t) = \sum_{\substack{n=1 \\ n \text{ odd}}}^{\infty} (-1)^{(n-1)/2} \frac{4V_0}{n\pi} \cos(n\omega_0 t)$$

where $\omega_0 = \frac{2\pi}{T} = \frac{2\pi}{1\,\text{ms}} = 2\pi \times 10^3$ rad/s

$f_0 = 1$ kHz

The signal $y(t)$ will contain frequency components at $f_c \pm f_0, f_c \pm 3f_0, f_c \pm 5f_0, \ldots$

If the first five nonzero components are to be passed by the filter, the bandwidth of the filter must be $\geq 2 \times 9$ kHz = 18 kHz.

**THE CORRECT ANSWER IS: D**

78. Refer to the Error Coding section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

Since the system uses even parity, an even number of "1" bits (including the parity bit) should be received.

An odd number of bits have to be corrupted to detect an error. Since an odd number of bits have been received $\Rightarrow$ 1 or 3 or 5 or … bits have been corrupted.

**THE CORRECT ANSWER IS: B**

**79.** Examinees are expected to be familiar with the differences between time and frequency division multiplexing.

The different stations in the AM radio band are transmitted at different frequencies, so this is frequency-division multiplexing.

**THE CORRECT ANSWER IS: C**

**80.** Refer to the Local Area Network (LAN) section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

A router is used to make the connection from one LAN to another LAN or WAN. Computers on the same LAN communicate with each other using a switch and do not make use of a router. Computers connect to the same network using a switch.

**THE CORRECT ANSWER IS: C**

**81.** Refer to the Computer Networking section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

In packet-switched networks, discrete data packets are received and stored by the packet switches and then transmitted when a connection to the next point in the network becomes available. Packets are re-ordered at the destination. Only circuit-switched networks require that end-to-end connection is established before transmission. All of the properties except for C and E apply.

**THE CORRECT ANSWERS ARE: A, B, D**

**82.** Refer to the Computer Networking section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

Internet Protocol (IP) operates at the network layer. Both Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) operate at the transport layer.

**THE CORRECT ANSWER IS: C**

**83.** Examinees are expected to be familiar with NIST standards.

Option C, thumbprint and PIN, is the only solution that has two different factors from the three types (something you know, something you have, something you are). This is something you are and something you know.

**THE CORRECT ANSWER IS: C**

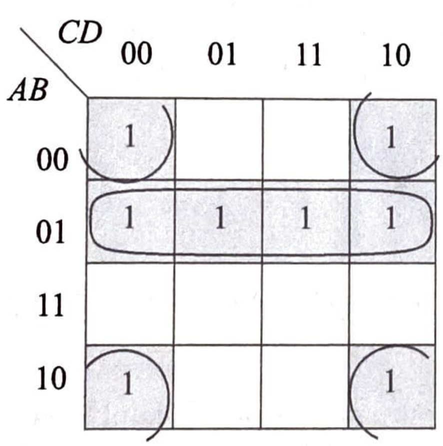
**84.** Refer to the Binary Number System section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$\frac{93}{128}$ can be broken into $\frac{64+16+8+4+1}{128}$, which by decimal is 0.1011101.

**THE CORRECT ANSWER IS: B**

**85.** Refer to the Switching Function Terminology section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

All minterms of the K-map can be covered with two groupings as shown below.




$$f(A,B,C,D) = \overline{A}\,B + \overline{B}\,\overline{D}$$

**THE CORRECT ANSWER IS: D**

**86.** Refer to the Flip-Flops section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

If the count is 10, then the D input to the D-type flip is 0, and the JK inputs to the JK flip-flop are both 1, as shown in the figure. After the next CLK signal is applied, the JK flip-flop will toggle from 1 to 0, and the D-type flip-flop will still have a 0 latched in its output. The count will be 00.

**THE CORRECT ANSWER IS: A**

**87.** Refer to the Finite State Machine section in the Mathematics chapter of the *FE Reference Handbook.*

| | | | |
|---|---|---|---|
| Present State | C | B | B |
| $x$ | 1 | 0 | 0 |
| Next State | B | B | B |
| $z$ | 1 | 1 | 1 |

**THE CORRECT ANSWER IS: D**

**88.** Refer to the Logic Operations and Boolean Algebra section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$F = 1$ whenever $B = 0$ and when both $A$ and $C = 0$.

**THE CORRECT ANSWER IS: D**

**89.** Refer to the Logic Operations and Boolean Algebra section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

The output is:

$$\overline{\left(\overline{\overline{XY}\bullet X}\right)\bullet\left(\overline{\overline{XY}\bullet Y}\right)} = \overline{XY}\bullet X + \overline{XY}\bullet Y = \overline{XY}\bullet(X+Y) = X \oplus Y$$

**THE CORRECT ANSWER IS: C**

**90.** Refer to the Logic Operations and Boolean Algebra section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

**THE CORRECT ANSWER IS: B**

91. Refer to the Logic Operations and Boolean Algebra section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

The OR gate does not change. The AND gate changes from 1 to 0, adding a delay $t_{PHL} = 21$ ns. The change in the AND gate causes the inverter to change state from 0 to 1, adding a delay $t_{PLH} = 10$ ns. The change in the NOT gate causes the NAND gate to change from 1 to 0, adding a delay $t_{PHL} = 16$ ns. Thus the total delay is $21 + 10 + 16 = 47$ ns.

**THE CORRECT ANSWER IS: 47**

92. Refer to the Computer Systems section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

Indexed addressing uses the contents of some register (*R* in this problem) as a pointer to the beginning (or end) of a list (array) of values in memory base. An offset, D, is added to the value of the base pointer to determine the location of an operand.

**THE CORRECT ANSWER IS: C**

93. Refer to the coding table in the Binary Number System section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

The EPROM will respond whenever $CS_4$ is asserted, or whenever the address issued by the μp is 100X XXXX = 8000 to 9FFF. (X = don't care)

**THE CORRECT ANSWER IS: C**

94. Refer to the Binary Number System section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

The direct address is bits 0 through 8, thus the direct address consists of a total of 9 bits. Therefore, the total number of words that can be addressed is $2^9$ or 512 words.

**THE CORRECT ANSWER IS: B**

95. Refer to the Memory/Storage Types section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

Since the stack is a LIFO buffer, the last value pushed was the value that was initially in D3. The registers are now going to be in reverse order.

**THE CORRECT ANSWER IS: C**

**96.** Refer to the Network Topologies section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

Full duplex contains two dedicated lines that cross between the transmitter and receiver pins. Serial interfaces require only three connections (transmit, receive, and ground).

**THE CORRECT ANSWERS ARE: A, E**

**97.** Refer to the Software Syntax Guidelines section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

$Y = 10 \rightarrow$ loop while is active $\rightarrow Y = 9$
$Y = 9 \rightarrow$ loop while is active $\rightarrow Y = 8$
.
.
.
.
$Y = 1 \rightarrow$ loop while is active $\rightarrow Y = 0$
$Y = 0 \rightarrow$ loop while NOT active, returns $Y = 0$

**THE CORRECT ANSWER IS: B**

**98.** Refer to the Software Syntax Guidelines section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

| First Round | Second Round |
|---|---|
| $Q = 1 + 2 = 3$ | $Q = 3 + 2 = 5$ |
| $K = 2 \times 3 = 6$ | $K = 6 \times 5 = 30$ |
| $3 > 3$ NO! | $5 > 3$ YES! |
| | $\therefore Q = 5$ |

**THE CORRECT ANSWER IS: D**

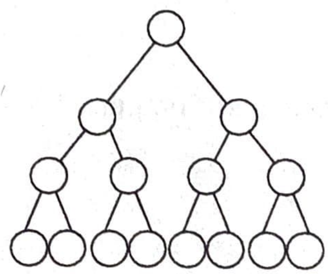
**99.** Refer to the Algorithms section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

A bubble sort iterates through the list and swaps values if greater. This continues until nothing is left to be changed.

**THE CORRECT ANSWER IS: A**

**100.** Refer to the Algorithms section in the Electrical and Computer Engineering chapter of the *FE Reference Handbook.*

Height = log $(n + 1) - 1$, or $n = 2^{h+1} - 1$. Alternatively, draw out the tree and count the number of branches from the final nodes to the root node.



**THE CORRECT ANSWER IS: D**

**FE EXAM PREPARATION MATERIAL**
**PUBLISHED BY NCEES**

*FE Reference Handbook*

*FE Practice Exams* for all modules:
Chemical
Civil
Electrical and Computer
Environmental
Industrial and Systems
Mechanical
Other Disciplines